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ORIGINAL ARTICLES.

I.—A New Cretaceous Plant from Nigeria.

By M. C. Stopes, D.Sc. (Lond.), Ph.D. (Mun.), F.L.S.

(PLATE XXXIII.)

THE available information regarding the fossil plants of Southern Nigeria is of the meagrest description. Consequently great interest lies in the collections of fossil plants brought back from Nigeria last year by Mr. A. E. Kitson, F.G.S., and it seems worth while to publish a brief account of what appears to be a new species of Monocotyledon from among them.

Mr. Kitson's collections of fossil plants, of both Cretaceous and Tertiary age, are extensive, and include specimens which obviously represent a large number of different genera, the majority being species of dicotyledonous leaves. It is greatly to be deplored, however, that the material is so fragmentary; the local accidents of deposition were evidently unfavourable to plant petrifaction.

The one species which forms the subject of the present short note is apparently part of the base of a monocotyledonous leaf. There are a number of specimens of this between the layers of reddish-brown impure shale of Cretaceous age which is literally packed with more or less macerated vegetable fragments (see Fig. 3, Pl. XXXIII). The exact locality of their occurrence is given by Mr. Kitson as in the Azuta River, east of the crossing of the Udi–Okwoga road over it, i.e. roughly 120 miles in a direct line north-west from Calabar on the coast of Southern Nigeria.

Regarding the geology of the region Mr. Kitson[1] writes: "The oldest known sedimentary rocks are Cretaceous marine and estuarine fossiliferous shales, mudstones, limestones, sandstones, and grits. They flank the Oban hills, and extend in a great mass northward into Northern Nigeria; also westward under the Udi highlands, where they grade into freshwater beds of similar character, and contain a valuable black coal-field, discovered by myself and Mr. E. O. Thiele. In the Abakaliki district, in marine Cretaceous strata, there are lodes of silver-lead, zinc, and iron ores, formed along fault-lines. Dolerite, basalt, agglomerate, and tuff occur as dykes, sills, or volcanic necks in the Cretaceous area of the eastern province."

Certain of the shales are rich in vegetable remains, and among the innumerable plant-fragments in them which are macerated out of all recognition are a number of net-like impressions varying in area from 1 × 2 up to 8 or 10 cm. These impressions consist of a blackened,

[1] A. E. Kitson, "Southern Nigeria; some considerations of its Structure, People, and Natural History": Geographical Journal, January, 1913, p. 19.

carbonaceous, and characteristically regular meshwork (see Figs. 1–3, Pl. XXXIII). In the majority of cases the mesh is isodiametric, and about 2 mm. across, but toward the edge or base of the specimens the mesh narrows and becomes reduced in size, as is shown in the Text-figure, p. 435, and Fig. 3, Pl. XXXIII. In a few cases the whole of the mesh is finer.

The first point to determine is whether this open mesh represents a normally perforate leaf or macerated portions which retain only the skeletal framework. The former interpretation would seem reasonable were there not a few cases in which a blackened, coaly film lies over part of the area and suggests that it was the surface tissue of a non-perforate leaf lamina. In living reeds a somewhat similar phenomenon can be observed on a smaller scale; the leaf-base in *Typha* partially decays, displaying a regularly perforated skeleton beneath the smooth lamina, and I feel little doubt that the fossils represent old leaf-bases of somewhat similar plants.

Turning now to described species of fossils with which to compare the new Nigerian plant, one finds a number of records of *Arundo*, *Typha*, *Phragmites*, etc., from the Tertiary of many countries. None of these specimens, however, are identical with our fossil, the forms generally being laminæ which only show fine striations formed by the longitudinally running veins and their regular transverse connexions. The same may be said of the forms described by Heer, Unger, Saporta, and others from the Cretaceous, as will be seen in the various original figures, references to which are given in detail in my Cretaceous Catalogue[1] under the generic names. Among the illustrations of comparable forms which I have been able to discover fig. 2*a*, pl. xviii, of Ludwig's[2] paper on the Tertiary species *Phragmites Oeningensis*, Al. Braun, bears considerable resemblance to a fragment of our fossil; but this figure is an *enlargement* of the detail of the leaf; the normal leaf of *P. Oeningensis* has, like the other described fossils of the kind, veins on a much smaller scale than has our new Nigerian form.

The only described fossil of which I am cognisant which bears a real resemblance to the Nigerian ones is that figured by Saporta in 1890,[3] pl. ii, fig. 4. This, both as regards the size of the mesh and the general appearance, comes very close to our fossil. Saporta's fragment, however, is a small one, only 1 × 2 cm. in area, and gives no indication of the potential size of the leaf. Saporta's plant is described under the name *Typhacites rugosus*, and he speaks of this plant and another which he puts in the same genus as "fragments de feuilles de Monocotylées, sans doute amies des eaux stagnantes, que je figure en les rapportant, non sans quelque doute aux Typhacées". The species were associated with the famous *Nelumbium provinciale*,

[1] Marie C. Stopes, *Catalogue of the Mesozoic Plants in the British Museum: The Cretaceous Flora*, pt. i, 1913, pp. 64, 167, 223, etc.

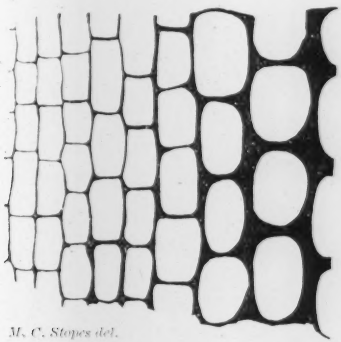
[2] Rudolf Ludwig, "Fossile Pflanzen aus der ältesten Abtheilung der Rheinsch - Wetterauer Tertiär - Formation": Palæontographica, vol. viii, p. 80, 1859–61.

[3] G. de Saporta, *Le Nelumbium provinciale des Lignites crétacés de Fuveau en Provence*, Mém. 5, Soc. Géol. France, 1890, pp. 1–10, pls. i–iii.

Sap. Whatever our Nigerian and Saporta's plants may ultimately prove to be, I think there is little doubt our plant resembles his so closely that, in the present state of our ignorance of the forms, the Nigerian plant should be included in his genus. Therefore I name it in honour of Mr. Kitson, its discoverer.

TYPHACITES KITSONI, n.sp. (Plate XXXIII.)

Diagnosis of such a species is difficult, but may provisionally be as follows: Impressions, presumably of partly macerated or old leaf-bases of considerable size, i.e. exceeding 4 cm. in width and of indefinite length. The regular meshwork of the surface very coarse, each mesh isodiametric, averaging about 2 mm. in diameter, but in parts narrowing down to 1 × 1·5 mm.



Drawing of a small portion of the edge of one of the specimens of *Typhacites Kitsoni* (M. C. Stopes). × 3.

Types.—The figured specimens are in the British Museum, Natural History.

Locality.—Azuta River where the Udi Road crosses it, Southern Nigeria.

Discoverer.—A. E. Kitson, Esq., F.G.S.

Horizon.—Cretaceous, Middle (?) or Upper.

Note.—Mr. Kitson authorizes me to state that his large collection of dicotyledons from this and other associated Cretaceous deposits and the Tertiary (?) of other districts in Southern Nigeria is now in the British Museum, and is available for anyone who wishes to describe it.

EXPLANATION OF PLATE XXXIII.

FIG. 1. Specimen of the meshwork of the leaf *Typhacites Kitsoni*, n.sp. Natural size.

,, 2. Portion of a similar specimen enlarged by 2 diameters.

,, 3. Part of the base of another specimen showing the finer mesh, enlarged by 2 diameters. On the right of the figure are seen the numerous macerated fragments of plants which are abundant in these shales.

II.—Some New Genera and Species of Cretaceous Cheilostome Polyzoa.

By W. D. Lang, M.A., F.G.S.

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(PLATE XXXIV.)

HERPETOPORA ANGLICA, the genotype of the new genus *Herpetopora*, described in this Magazine,[1] was the name proposed for a new species that hitherto had been wrongly recorded as *Hippothoa dispersa* (Hagenow).[2] It was then remarked that the English form did not belong to the genus *Hippothoa*, of which the genotype is *H. divaricata*[3]; but, while *Herpetopora* was proposed for the English species, no suggestion was made for a genus to include *Hippothoa dispersa* (Hagenow) that certainly could not remain under *Hippothoa*. It is proposed here to describe in detail Hagenow's species, to give it a generic name, and, further, to consider some allied forms.

In 1860 Gabb & Horn published a description of *Hippothoa irregularis* (since redescribed and figured as *Pyripora irregularis*[4]) from the Danian of New Jersey. An examination of a specimen shows that it differs from *Herpetopora* in possessing a boldly beaded termen, and in this it resembles an undescribed form from Faxe and the form hitherto known as *Hippothoa dispersa* (Hagenow). *Pyripora*, however, was founded by d'Orbigny[5] for three geno-syntypes, of which one—*Escharina crenulata*, Reuss—was selected as the genotype[6] a year (or two years) after *Pyripora* was introduced. *Escharina crenulata*, Reuss, differs from the three forms under consideration (those from New Jersey, Faxe, and Rügen respectively) in several characters, notably in the form of branching, and neither these nor *Herpetopora*[7] can fall under *Pyripora*. Moreover, of the three, the Rügen form differs from the other two in having dimorphic zoœcia, though neither this feature nor the beaded termen is shown in Marsson's figures. If specimens are suitably painted (with indigo water-colour, for instance) both these characters are plainly seen. The two genera *Allantopora* and *Marssonopora* are proposed, the former to include the Danian species from New Jersey and from Faxe and the latter for the Senonian form from Rügen.

Synonymy.[9] ALLANTOPORA, n.g.[8]

Hippothoa (partim), Gabb: Gabb & Horn, Johnson, Nickles & Bassler.
Pyripora (partim), Conrad in Cook, Gabb & Horn, Meek, Nickles & Bassler, Ulrich & Bassler in Weller, Vine.

[1] Geol. Mag., Dec. VI, Vol. I, pp. 5 and 6, 1914.
[2] For references see p. 438.
[3] Lamouroux, *Exposition Méthodique des genres de l'Ordre des Polypiers*, p. 82, 1821.
[4] For references see p. 439.
[5] D'Orbigny, *Prodrome de Paléontologie Stratigraphique universelle*, vol. ii, p. 263, 1850.
[6] Bronn & Roemer, *Lethæa Geognostica*, vol. ii, pt. v, p. 106, 1851–2.
[7] See a criticism by Canu, *Revue critique de Paléozoologie*, vol. xviii, p. 90, 1914.
[8] ὁ ἀλλᾶς, 'a sausage'; suggested by the strings of zoœcia.
[9] For references see p. 437.

Diagnosis.—Incrusting, uniserial Cheilostome Polyzoa, normally with bilateral branching; zoœcia monomorphic, divided into a proximal caudal and distal capitular portion; termen beaded; extra-terminal front wall well developed proximally, plain with no median ridge or groove; intra-terminal front wall represented by a narrow bevel, tending to become broader proximally.

Genotype.—*Hippothoa irregularis*, Gabb & Horn.

Distribution in time.—Danian.

Remarks.—*Hippothoa* and *Pyripora*, to which genera the species here placed under *Allantopora* have been referred, differ, the former in having a completely calcareous intra-terminal front wall, and the latter in its method of branching and by the presence of avicularia.

Key to the genus Allantopora.

1. Aperture comparatively large; capitular portion of zoœcium pyriform. *A. irregularis* (Gabb & Horn).
2. Aperture comparatively small; capitular portion of zoœcium cylindrical. *A. stomatoporoides*, n.sp.

ALLANTOPORA IRREGULARIS (Gabb & Horn). (Pl. XXXIV, Fig. 1.)

Synonymy.

Hippothoa irregularis, Gabb & Horn, "Description of new Cretaceous Corals from New Jersey": Proc. Acad. Nat. Sci. Philadelphia, vol. for 1860, p. 366.

H. irregularis, G. & H.: Gabb, "Descriptions of New Species of American Tertiary and Cretaceous Fossils": Journ. Acad. Nat. Sci. Philadelphia, ser. II, vol. iv, p. 400, pl. lxix, figs. 18–20, 1860; Timber Creek, New Jersey.

Pyripora irregularis, G. & H.: Gabb & Horn, "Monograph of the Fossil Polyzoa of the Secondary and Tertiary Formations of North America": Journ. Acad. Nat. Sci. Philadelphia, ser. II, vol. v, pp. 122, 157, pl. xx, fig. 40, 1862.

P. irregularis, Gabb & Horn: Meek, *Check List of Invertebrate Fossils of North America*, p. 3, 1864; New Jersey.

P. irregularis, Gabb & Horn: Conrad in Cook, *Geology of New Jersey*, p. 723, 1868.

P. irregularis, Gabb & Horn: Vine, "Fifth . . . Report of the Committee . . . on Fossil Polyzoa": Rep. Brit. Assoc. for 1884, p. 169, 1885; Timber Creek.

Hippothoa irregularis, Gabb & Horn: Nickles & Bassler, "A Synopsis of American Fossil Bryozoa": Bull. United States Geol. Surv., No. 173, pp. 153, 154, 1900. Cretaceous: Timber Creek, New Jersey.

Pyripora irregularis (G. & H.): Nickles & Bassler, op. cit., p. 157, 1900. Cretaceous: Timber Creek and Mullica Hill, New Jersey.

P. irregularis, G. & H.: Johnson, "Annotated List of the Types of Invertebrate Cretaceous Fossils in . . . Acad. Nat. Sci. Philadelphia": Proc. Acad. Nat. Sci. Philadelphia, vol. lvii, p. 5, 1905.

P. irregularis, Gabb & Horn: Ulrich & Bassler in Weller, "A Report on the Cretaceous Paleontology of New Jersey": Geol. Surv. New Jersey, Paleontology, vol. iv, Cretaceous Faunas, pp. 167, 337, pl. xxiv, fig. 5, 1907. Vincentown Limesand: North bank of Rancocas Creek north-west of Vincentown, Timber Creek, and near Mullica Hill, New Jersey.

Revised diagnosis.—*Allantopora* in which the capitular portion of the zoœcia is long compared with the caudal portion, pear-shaped, and

comparatively large (about ·6 mm. in a proximal-distal direction and ·4 mm. at right angles to this); termen bearing eleven beads, one median and proximal, and five paired decreasing in size distally; proximal part of the extra-terminal front wall short compared with the aperture; intra-terminal front wall a very narrow bevel; aperture large, occupying most of the capitular portion of the zoœcium and nearly a half of its whole length, oval. Sealed zoœcia rare or absent.

Distribution.—Danian, Vincentown Limesand: New Jersey, U.S.A.

Remarks.—The beaded termen, characteristic of the genus *Allantopora*, is not shown in the figures of *A. irregularis* hitherto published; it is very apparent, however, in the British Museum specimen here figured (D. 19186) from the Vincentown Limesand, New Jersey, and undoubtedly belonging to this species.

ALLANTOPORA STOMATOPOROIDES,[1] n.sp. (Pl. XXXIV, Fig. 2.)

Diagnosis.—*Allantopora* with a short caudal portion to the zoœcia and a capitular portion that is cylindrical rather than pear-shaped and tapers very gradually into the caudal portion; the capitular portion is small, about ·5 mm. in a proximal-distal direction, and ·3 mm. at right angles to this; termen with about twelve beads; extra-terminal front wall very large, occupying at least the proximal half of the capitulum as well as lateral areas in the distal portion; aperture oval, small in correlation with the great development of the extra-terminal front wall.

Type-specimen.—British Museum specimen D. 9110; Caroline Birley Collection.

Distribution.—Danian: Faxe, Seeland, Denmark.

MARSSONOPORA,[2] n.g.

Synonymy.[3]

Aulopora (partim), Geinitz, Pictet.
Cellepora (partim), Boll, Hagenow.
Hippothoa (partim), Marsson, d'Orbigny.

Diagnosis.—Incrusting, uniserial Cheilostome Polyzoa, normally with bilateral branching; zoœcia dimorphic; normal zoœcia with capitular and caudal portions, sometimes sealed; termen beaded; extra-terminal front wall well developed proximally, plain, with no median groove or ridge; intra-terminal front wall represented by a narrow bevel, somewhat wider proximally; apertures oval-ovate; avicularia small, situated on the caudal portions of the normal zoœcia.

Genotype.—*Cellepora dispersa*, Hagenow.

Distribution.—Upper Senonian.

Remarks.—Of the different genera in which *Marssonopora dispersa* has been placed, *Aulopora* is a genus of Palæozoic Corals; *Cellepora* was founded by Linnæus[4] for Recent multiserial forms with complete front walls; and *Hippothoa* also has complete front walls.

[1] Invented to mean 'resembling a *Stomatopora*', from the cylindrical shape of the zoœcia.

[2] Named after Theodor Marsson, the monographer of the Chalk Polyzoa of Rügen.

[3] For references see p. 439.

[4] Linnæus, *Systema Naturæ*, 12th ed., vol. i, pt. ii, p. 1285, 1766.

MARSSONOPORA DISPERSA (Hagenow). (Pl. XXXIV, Fig. 3.)

Synonymy.

Cellepora dispersa, nob.: Hagenow, "Monographie der Rügen'schen Kreide-Versteinerungen, Abt. i, Phytolithen und Polyparien": Neues Jahrb. f. Min., etc., Jahrgang, 1839, p. 280; Rügen.

Aulopora dispersa, v. Hag.: Geinitz, *Grundriss der Versteinerungskunde*, p. 629, pl. xxiii*b*, fig. 55, 1846; Obere Kreide: Rügen. [Figure shows the avicularia.]

non *Escharina dispersa* (v. Hagenow): Reuss, *Die Versteinerungen der Böhmischen Kreideformation*, pt. ii, p. 67, pl. xv, fig. 26, 1846. [=*Dacryopora reussi*, see p. 443.]

Cellepora dispersa, v. Hg.: Boll, *Geognosie der deutschen Ostseeländer zwischen Eider und Oder*, Oberer Weisse Kreide, p. 207, 1846.

? *Hippothoa laxata*, d'Orb.: d'Orbigny, *Pal. Franç., Terr. Crét.*, tom. v, 1852, pl. dcexi, figs. 12–15; 1853, p. 386; 1854, p. 1097. Senonian: Meudon, Tours. [Marsson (op. cit. infra, p. 91) gives this species as a synonym of *Cellepora dispersa*, but, judging from the figure, it more resembles a *Herpetopora* with sealed zoœcia.]

H. [*Aulopora*] *dispersa*: d'Orbigny, 1853, op. cit., p. 383; Craie sénonienne de Rügen.

H. [*Aulopora*] *dispersa*, Hagenow: Pictet, *Traité de Paléontologie* . . . vol. iv, 2nd ed., p. 103, 1857. Craie: Rügen.

non *H. labiata*: Novák, "Beitrag zur Kenntniss der Bryozoen der böhmischen Kreideformation": Denk. Akad. Wiss. Wien, vol. xxxvii, pt. ii, p. 86, pl. iii, figs. 1–5, 1877, as stated by Marsson, 1887, op. cit. infra, p. 91. [=*Herpetopora labiata*.]

H. dispersa, v. Hagenow sp.: Marsson, "Die Bryozoen der Weissen Schreibkreide der Insel Rügen": Pal. Abh., vol. iv, pt. i, p. 91, pl. ix, fig. 9, 1887; Rügen.

? non *H. dispersa*, Hagenow: Vine, "Fossil Polyzoa; further additions . . .": Proc. Yorkshire Geol. Soc., N.S., vol. xii, pt. ii, p. 155, 1892; Chatham, Salisbury, and Norfolk. [Probably the Chatham specimens are *Herpetopora anglica* and the others *H. clavigera*.]

? non *Membranipora dispersa*, Hag.: Vine, "Report of the Committee . . . on the Cretaceous Polyzoa": Rep. Brit. Assoc. for 1892, pp. 316, 322, 335, 1893. *Coranguinum* and *quadratus* zones: Chatham and East Harnham. [For probable identities see last entry.]

non = *Crisia Johnstoniana*: Mantell, *The Medals of Creation*, vol. i, p. 285, text-fig. 64 on p. 284, fig. 10, 1844; as stated by Vine, 1893, op. cit., p. 316.

? non *Membranipora dispersa*, Marss.: Jukes-Browne, *The Cretaceous Rocks of Britain*, vol. iii, The Upper Chalk of England (Mem. Geol. Surv. United Kingdom), p. 491, 1904. *Cortestudinarium* zone, Charlton, and *quadratus* zone, Salisbury. [Probably the record from the former horizon is *Herpetopora anglica* and, from the latter, *H. clavigera*.]

? *M. dispersa*, Hag.: Jukes-Browne, op. cit., pp. 268, 491, 1904. *Ostrea lunata* zone: Trimingham, Norfolk.

non *Hippothoa dispersa*, Hagenow: Chatwin & Withers, "The Zones of Chalk . . . between Goring and Shiplake": Proc. Geol. Assoc., vol. xx, pt. v, pp. 394, 416, 1908. *Terebratulina* zone: Gatehampton, Oxon. [The specimen on which this record is founded, British Museum specimen D. 20611, is *Herpetopora anglica*.]

Diagnosis.—*Marssonopora* in which the caudal portions of the zoœcia are very long and the capitular portions are pear-shaped; termen bearing seventeen or eighteen beads decreasing in size distally, in continuous series proximally, but absent from the extreme distal edge; extra-terminal front wall well developed proximally; aperture

oval-ovate, occupying about two-thirds of the length of the capitulum; avicularia very small; one (or occasionally two) on many of the caudæ, with oval apertures, constricted rather distally of the middle. Sealed zoœcia rare.

Distribution.—Upper Senonian, zone of *Belemnitella mucronata*: Rügen I., German Baltic.

Remarks.—Marsson (for reference see synonymy) does not mention either the beaded termen or the avicularia, nor do his figures show these characters (though the avicularia appear in Geinitz's figure, see above). They become, however, strikingly clear when the specimen is painted with some dark colour. Doubtless the lack of some such method was the cause of Marsson's overlooking these points; for there can be no doubt of the identity of the Rügen specimens (British Museum specimens D. 11498, D. 15376, and D. 15423) showing these characters with *M. dispersa* as interpreted by Marsson.

It has been shown already that of the three genosyntypes of d'Orbigny's genus *Pyripora*, *Escharina crenulata*, Reuss, must be taken as the genotype. The other two species were *Escharina dispersa*, Reuss (*non* Hagenow), and *Escharina perforata*, Reuss. A glance at Reuss' figure of *Escharina dispersa* will show that it is not *Cellepora dispersa*, Hagenow (just described as *Marssonopora dispersa*), since the front wall is complete. But beyond this, and that it is uniserial, it is difficult to say from the figure what its affinities are. There is, however, an undescribed uniserial Cheilostome occurring rarely in the English Chalk, with a complete front wall, and *Escharina dispersa*, Reuss, may be placed provisionally in the genus now made for its reception.

Dacryopora, n.g.[1]

Synonymy.[2]

Diazeuxia (partim), Canu.
Escharina (partim), Bronn, ? Morris, Reuss, Vine.
Hippothoa (partim), Gabb & Horn, Manzoni, d'Orbigny, Pictet, Vine.
Membranipora (partim), ? Vine.
Microporella (partim), Vine.
Pyripora (partim), d'Orbigny.

Diagnosis.—Incrusting, uniserial Cheilostome Polyzoa, normally with bilateral branching; zoœcia monomorphic, divided into a proximal caudal and a distal capitular portion; termen, except distally, indicated by a contour on the complete front wall at which the slope of the front wall changes; distally it coincides with the lateral and distal edges of the orifice, and bears one or more pairs of spines; extraterminal front wall comparatively small and slightly arched; intraterminal front wall entirely calcareous, highly arched, often bearing a median ridge; aperture semicircular or slightly cribrilinid.[3]

Genotype.—*Dacryopora gutta*, new species.

Distribution in time.—? Cenomanian to Senonian.

[1] τό δάκρυ, 'a tear,' 'a drop,' from the shape of the zoœcium.
[2] For references see these authors' names under the several species.
[3] i.e. of the general shape of the orifice in the family Cribrilinidæ.

Remarks.—Without seeing the specimens themselves it is impossible to know the detailed structure of the three species here included with *D. gutta* in *Dacryopora*. As far as can be seen, however, they conform better with *Dacryopora* than with any other genus, and, consequently, are provisionally placed here. Of the various genera under which they have been placed, *Membranipora*[1] and *Pyripora*[2] have incompletely calcareous front walls, *Microporella*[3] and *Escharina*[4] were founded for several Recent multiserial species, and *Hippothoa*[5] and *Diazeuxia*[6] have myriozoid[7] apertures.

Key to the genus Dacryopora.

I. Zoœcia elongate, capitula nearly thrice as long as broad; caudæ very short. *D. simplex* (d'Orbigny).

II. Zoœcia short, capitula one to two and a quarter times as long as broad.

a. Zoœcia with very long caudæ.

1. Zoœcia more or less parallel-sided . *D. gutta*, n.sp.
2. Zoœcia fusiform . . . . *D. elegans* (d'Orbigny).

b. Zoœcia with very short caudæ . . *D. reussi*, nom. nov.

DACRYOPORA SIMPLEX (d'Orbigny).

Synonymy.

Hippothoa simplex, d'Orb.: d'Orbigny, *Pal. Franç., Terr. Crét.*, vol. v, pl. dcexi, figs. 5–8, 1852; op. cit., p. 385, 1853; op. cit., p. 1092, 1854. Cenomanian: Sarthe.

H. simplex, d'Orbigny: Pictet, *Traité de Paléontologie* . . . , 2nd ed., vol. iv, p. 103, 1857. Cenomanian.

H. simplex, d'Orb.: Gabb & Horn, Proc. Acad. Nat. Sci. Philadelphia for 1860, p. 366.

H. simplex, d'Orb.: Gabb, Journ. Acad. Nat. Sci. Philadelphia, ser. II, vol. iv, p. 400, 1860.

H. simplex, d'Orb.: Gabb & Horn, Journ. Acad. Nat. Sci. Philadelphia, ser. II, vol. v, p. 157, 1862.

non *H. simplex* (d'Orb.): Vine, Quart. Journ. Geol. Soc., vol. xlvi, pp. 486, 461, 1890. Red Chalk: Hunstanton. (Vine's specimen No. 40, B.M. specimen D. 2052.)

? *H. simplex*, d'Orb.: Vine, Proc. Yorks. Geol. Soc., N.S., vol. xi, pt. iii, pp. 385–6, 396, 1891. Red Chalk: Hunstanton.

? *Membranipora* (?) *simplex*, d'Orb.: Vine, Rep. Brit. Assoc. for 1890, p. 396, 1891. Red Chalk: Hunstanton.

? *Hippothoa simplex*, d'Orb.: Vine, Proc. Yorks. Geol. Soc., N.S., vol. xii, pt. ii, p. 156, 1892. Gault: Barnwell, Cambridge.

[1] De Blainville, *Manuel d'Actinologie*, p. 447, 1834. Includes eleven genosyntypes.

[2] D'Orbigny, loc. cit., see p. 436, 1850.

[3] Hincks, Ann. Mag. Nat. Hist., ser. IV, vol. xx, p. 526, 1877. Genotype, *Eschara ciliata*, Pallas.

[4] Edwards, in Lamarck, *Histoire Naturelle des Animaux sans Vertèbres*, 2nd ed., vol. ii, p. 230, 1836.

[5] Lamouroux, *Exposition Méthodique des genres de l'Ordre des Polypiers*, 1821, p. 82. See p. 436.

[6] Jullien, *Mission Scientifique du Cap Horn*, 1882–3, tom. vi, Zoologie—Bryozoaires, p. 28, 1888. Genotype, *Cellepora hyalina*, Linnæus, *Systema Naturæ*, 12th ed., vol. i, pt. ii, p. 1286, 1767.

[7] i.e. of the general shape of the apertures in the family Myriozoidæ.

Diazeuxia simplex (d'Orb.): Canu, "Revision des Bryozoaires du Crétacé figurés par d'Orbigny, deuxième partie—Cheilostomata": Bull. Soc. Géol. France, ser. III, vol. xxviii, p. 459, 1900. Cenomanian.

? non *Hippothoa simplex*, d'Orb.: Jukes-Browne & White, *The Geology of the Country around Henley-on-Thames and Wallingford*: Mem. Geol. Surv. Engl. and Wales, 1908, p. 56. *M. coranguinum* zone: Henley district.

Distribution.—Cenomanian: Sarthe.

DACRYOPORA GUTTA,[1] n.sp. (Pl. XXXIV, Figs. 4, 5.)

Diagnosis.—*Dacryopora* with very long fine caudæ, and capitula that are somewhat parallel-sided; extra-terminal front wall very flat, tending to spread out on the incrusted surface; termen with a pair of small spines on the distal edge of the aperture and another pair at the proximal-lateral corners; intra-terminal front wall well arched, sometimes, in addition, somewhat flattened laterally, often showing a median ridge and in some zoœcia a median crack or groove; aperture small, about one-fifth as long as the capitulum, semicircular or very slightly cribrilinid; sealed zoœcia absent or rare.

Type-specimen.—British Museum specimen D. 27932; Senonian, zone of *Micraster cortestudinarium*. Pit west of large pit on Offham Hill, Lewes. C. P. Gaster Coll.

Distribution.—Senonian, zone of *M. cortestudinarium*. Luton, south-east of Chatham, Kent; in the collection of Dr. Rowe, of Margate. Pit west of large pit on Offham Hill, Lewes; B.M. specimens D. 27932, D. 27933; C. P. Gaster Coll. Cliffs between Cuckmere Haven and Hope Gap, Sussex; B.M. specimens D. 27934–41; C. P. Gaster Coll.

Senonian, top of *M. cortestudinarium* zone or base of *M. coranguinum* zone. Chatham, Kent; B.M. specimens D. 11409, D. 27955–63; W. Gamble Coll.

Senonian, zone of *M. coranguinum*. Strood, north-west of Chatham, Kent; in the collection of Dr. Rowe, of Margate.

The above are the only specimens I have seen of what is probably rather a rare form.

Synonymy. DACRYOPORA ELEGANS (d'Orbigny).

Hippothoa elegans, d'Orb.: d'Orbigny, *Pal. Franç., Terr. Crét.*, vol. v, pl. dcexi, figs. 1–4, 1852; op. cit., p. 384, 1853; op. cit., p. 1092, 1854. Cenomanian: Mans.

H. elegans, d'Orb.: Pictet, *Traité de Pal.* . . . , 2nd ed., vol. iv, p. 103, pl. xc, fig. 8, 1857; Cenomanian. [Figure is a copy of d'Orb., pl. dcexi, figs. 1–2.]

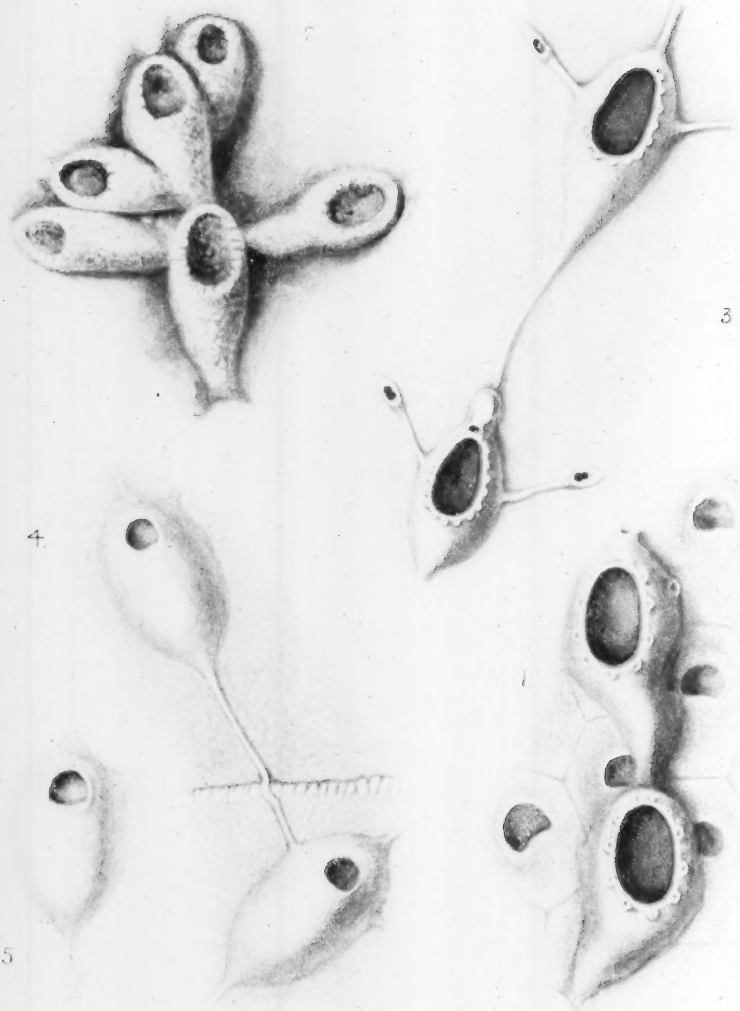
H. elegans: Manzoni, Sitz. d. K. Akad. Wiss. Wien, vol. lxi, pt. i, p. 329, 1870. Cretaceous.

H. elegans, d'Orb.: Vine, Quart. Journ. Geol. Soc., vol. xlvi, p. 484, 1890.

non *Membranipora* (*Hippothoa*) *elegans*, d'Orb.: Gamble, *Supplementary List of the Bryozoa of the Chatham Chalk*, p. 5, 1896. Lower Senonian: Chatham. [A specimen labelled by Gamble as the *Hippothoa elegans* of his list published in 1896 is a *Stomatopora*.]

Diazeuxia elegans (d'Orb.): Canu, "Revision des Bryozoaires du Crétacé figurés par d'Orbigny, deuxième partie—Cheilostomata": Bull. Soc. Géol. France, ser. III, vol. xxviii, p. 459, 1900.

[1] *gutta*, 'a drop'—an echo of the generic name.



C. M. Woodward del.

Cretaceous Cheilostome Polyzoa.

Allantopora, *Marssonopora*, *Diaerapora*.

? non *Membranipora* (*Hippothoa*) *elegans*, d'Orb. : Jukes-Browne, *The Cretaceous Rocks of Britain*, vol. iii, The Upper Chalk of England (Mem. Geol. Surv. United Kingdom), p. 491, 1904. *M. cortestudinarium* zone : Charlton.

Distribution.—Cenomanian : Le Mans, Sarthe, France.

Remarks.—The aperture in d'Orbigny's figure appears to be circular, as it does in Reuss' figure of *Escharina dispersa*. These two species are here provisionally placed in *Dacryopora* on the assumption that the apertures are subcircular or semicircular, with a tendency to a cribrilinid shape.

DACRYOPORA REUSSI, new name.

Synonymy.

Escharina dispersa (v. Hagenow) : Reuss, *Die Versteinerungen der Böhmischen Kreideformation*, pt. ii, p. 67, pl. xv, fig. 26, 1846. Lower Plänerkalk : Schillinge, bei Bilin, Bohemia.

non *Cellepora dispersa* : Hagenow, *Neues Jahrbuch, Jahrg.* 1839, p. 280 ; Rügen.

Escharina dispersa, Reuss : Bronn, *Index Palæontologicus* . . . A. Nomenclator Palæontologicus, p. 472, 1848.

E. dispersa, Reuss : Bronn, *Index Palæontologicus* . . . B. Enumerator Palæontologicus, p. 131, 1849 ; Kreide.

Pyripora [*Escharina*] *dispersa*, Reuss : d'Orbigny, *Prodrome de Pal.* . . . , vol. ii, p. 263, 1850. Senonian : Bilin, Bohemia.

? *Escharina dispersa*, Reuss : Morris, *A Catalogue of British Fossils*, 2nd ed., p. 123, 1854. Chalk detritus : Charing, Kent ; Harris Coll.

? *Microporella dispersa*, Reuss : Vine, Proc. Yorks. Geol. Soc., vol. xi, pt. ii, p. 259, 1890. Upper Greensand : *fide* Morris, 1854.

? *Escharina dispersa*, Reuss : Vine, Rep. Brit. Assoc. 1890, p. 391, 1891. Chalk detritus : Charing, Kent ; *fide* Morris, 1854.

? *E. dispersa*, Reuss : Vine, Proc. Yorks. Geol. Soc., N.S., vol. xii, pt. ii, p. 158, 1892. Chalk detritus : Charing, Kent ; *fide* Morris, 1854.

Distribution.—Cenomanian, Lower Plänerkalk : Schillinge, near Bilin, Bohemia.

Remarks.—See under *D. elegans* (d'Orbigny).

Key to the Genera described in this Paper, including Herpetopora.

A. Calcareous portion of intra-terminal front wall confined to a narrow bevel.
  I. No avicularia present.
    a. Termen plain . . . . . *Herpetopora.*
    b. Termen beaded . . . . *Allantopora.*
  II. Avicularia present ; termen beaded . *Marssonopora.*
B. Intra-terminal front wall entirely calcareous . *Dacryopora.*

EXPLANATION OF PLATE XXXIV.

FIG.

1. *Allantopora irregularis* (Gabb & Horn). Two zoœcia of a zoarium encrusting *Coscinopleura digitata* (Morton). × about 35 diameters. British Museum specimen No. D. 19186. Danian, Vincentown, Limesand. Near Blackwoods Town, New Jersey, U.S.A.
2. *Allantopora stomatoporoides*, n.sp. A piece of zoarium showing bilateral branching which is somewhat irregular in the more distal zoœcium. × about 35 diameters. The type-specimen ; British Museum specimen No. D. 9110. Danian. Faxe, Seeland, Denmark. Caroline Birley Coll. The poor preservation of the specimen, which is of a crystalline, granular consistency, makes it impossible to show greater detail.

FIG.

3. *Marssonopora dispersa* (Hagenow). A piece of a zoarium showing bilateral branching and consisting of two normal zoœcia and the caudal ends of five others, three of which bear small avicularia. The lower normal zoœcium (of which the capitular end only is shown) bears an ovicell. × about 43 diameters. British Museum specimen No. D. 11498. Senonian, zone of *Belemnitella mucronata*. Rügen I., German Baltic.
4. *Dacryopora gutta*, n.sp. A piece of zoarium showing bilateral branching and consisting of two zoœcia, encrusting a piece of shell of *Inoceramus lamarckii*, Parkinson. The caudal portion of one zoœcium traverses a ridge in the shell and consequently appears wavy. × about 33 diameters. British Museum specimen D. 27955. Senonian, top of zone of *Micraster cortestudinarium* or base of zone of *M. coranguinum*, Chatham, Kent. W. Gamble Coll.
5. *Dacryopora gutta*, n.sp. A single zoœcium from the type-specimen × about 37 diameters. British Museum specimen D. 27932. Senonian, zone of *Micraster cortestudinarium*. Pit west of large pit on Offham Hill, Lewes, Sussex. C. T. Gaster Coll.

III.—Saurischia and Ornithischia.

By Dr. F. Huene.

In 1888 the late Professor H. G. Seeley pointed out for the first time (Rep. Brit. Assoc. Adv. Sci., 1888, pp. 698–9) that Owens' order 'Dinosauria' should be divided into two great natural groups, especially on account of their pelvis. He called them Saurischia (= 'Theropoda' + 'Sauropoda') and Ornithischia (= 'Orthopoda'). He maintained his classification until his death in 1909, but nobody followed him. Only in 1907 did the present writer accept this classification and gave new evidences for it, but still was of opinion that these two groups only were ramifications of one natural unity, the 'Dinosauria'. But now, for several years, the writer has come to the conclusion that the 'Dinosauria' are not of monophyletic origin, but have developed from different points, and should therefore be considered as two distinct natural orders. Superficial similarities have been valued too highly, such as general form and size of the body, bipedal locomotion in two large groups, certain similarities in the formation of the foot, the femur, the humerus, and the shoulder-girdle.

The most striking difference between the Saurischia and the Ornithischia is in the pelvis, as is now generally well known. Even in their oldest known representatives there is no convergence at all in this respect. In the Ornithischia the facial part of the skull is prolonged and without præorbital openings, except in the most primitive forms with a very small fenestra; the dentition is multiplied and specialized; the extremities of the jaws are toothless (except in the primitive *Hypsilophodon*), and in the lower jaw (in one group also in the upper jaw) a new symphysial bone has been formed; the præmaxilla is of enormous size, its posterior extremity being intercalated between maxilla and nasal, and even reaching the lacrymal or the adlacrymal; the internal bony nasal openings are of enormous size, and the formation of the rest of the palate is characteristic; the processus coronoideus in the lower jaw is high, the quadrate is free; and the supraorbital forms part of the roof of the skull (as

shown by the writer in the Stegosauria, the Trachodontidæ, and the Ceratopsia). All of these features in the skull are differences from the Saurischia and at the same time show the higher adaptation and specialization of the Ornithischia. So long ago as 1908 the writer stated that no Ornithischia are known in the same primitive stage as certain of the oldest Saurischia.

In the vertebral column Saurischia of the highest specialization do not possess ossified tendons as do all bipedal Ornithischia, even the relatively primitive *Hypsilophodon*. This must be due to a different manner of locomotion and of feeding; the different kind of motion must have the same reason as the transformation of the pelvis and its stronger fixation to the vertebral column. Moreover, abdominal ribs are not yet known in Ornithischia, but they occur in Saurischia even in some of their latest forms.

In a recent paper[1] the writer has tried to demonstrate that the Saurischia and the Ornithischia came from the Pseudosuchia,[2] the former from their most primitive representatives by minor specializations, the latter from more specialized Pseudosuchians by a stage of bipedal hopping creatures in which the pelvis became adapted to this new locomotion by retroversion of the pubis and development of a prepubis. From this stage, as the writer suggests, the birds were also adapted for climbing on trees, then becoming capable of a parachute-flight, in consequence of this acquiring feathers and then later learning true flight (Abel's ideas combined with the writer's).

The name 'Dinosauria' should be absolutely abandoned, as is the case, for instance, with that of 'Enaliosauria'.

In 1908 the writer showed that the Sauropoda must have developed from the Plateosauridæ, an opinion he still retains, although some minor changes in our knowledge of the Saurischia have taken place. The writer now proposes two great sub-orders within the Saurischia: Cœlurosauria and Pachypodosauria (see *Centralbl. f. Min.*, etc., 1914, pp. 154–8), the former with four families: Hallopoda, Podokesauridæ (*Podokesaurus*, *Procompsognathus*, *Saltopus*, *Cœlophysis*, *Tanystrophæus*), Compsognathidæ, Cœluria (incl. *Ornithomimus*); the second sub-order would comprise again two lines of development, one leading from *Thecodontosaurus* to the Plateosauridæ and Sauropoda, the other from *Palæosaurus* to the Megalosauridæ.

IV.—On a Boring at Marston near Devizes.

By A. J. Jukes-Browne, F.R.S., F.G.S. (deceased).

THIS boring, though confined to the Kimeridge Clay, is of some interest, partly because it has proved the thickness of that clay to be much greater than it was supposed to be in this part of Wiltshire, and partly because it has yielded a species of *Aporrhais* or *Harpagodes* which has not previously been found in England.

[1] "Beiträge zur Geschichte der Archosaurier": Geol. u. Pal., Abh. 1914.

[2] Dr. G. A. Boulenger and Mr. D. M. S. Watson propose to reintroduce Owen's term 'Thecodontia', but the types on which he erected this order are: *Stagonolepis*, *Belodon*, *Cladyodon*, *Thecodontosaurus*, *Palæosaurus*, and *Bathygnathus*. They belong to very different orders.

The Kimeridge Clay is believed to be about 300 feet thick at Swindon, and the same thickness is assigned to it in the Index to Sheet 282 of the Geological Survey map, Devizes being about 20 miles south of Swindon. In the memoir on the *Country around Devizes* I did not venture to suggest any thickness for the Kimeridge Clay, of which only a small area comes within the limits of the sheet, and I was not responsible for the Index on the colour-printed edition of 1905, nor for the horizontal section at the foot of that map, which exaggerates the slight syncline that exists below Wotton and Pottern, and also seems to bring the base of the Kimeridge Clay too near the surface under Seend Hill, probably in order to make the position of its base agree with the assumed thickness of 300 feet.

The village of Marston is about 3½ miles south-west of Devizes, and the site of the boring is at Manor Farm, near the cross-roads, where the level of the ground is marked as 176 feet above O.D. The base of the Portland Sands comes in about three-quarters of a mile to the south-east, at a level of about 210 feet, and as the strata must be nearly horizontal near Marston the top of the boring will be about 34 feet below the summit of the Kimeridge Clay.

The boring had been carried to a depth of 180 feet before I was consulted about the prospect of finding water, and Messrs. J. W. Titt and Co. of Warminster were the engineers and contractors. In advising the continuance of the boring I certainly expected that the base of the Kimeridge Clay would be reached at a less depth than 400 feet, and there is every reason to suppose that the underlying Corallian limestones would furnish a plentiful supply of water when they were reached. Unfortunately the Clay has proved to be thicker than was expected, and as there was no sign of nearing its base at 400 feet the proprietor could not be induced to proceed farther in the attempt, so that the boring was abandoned at 412 feet.[1]

No samples were taken from the upper part of the boring down to about 150 feet, and all the information that Messrs. Titt could give me was that the material passed through varied very little and was similar to a sample sent from about 154 feet, which is a sandy grey clay, the sand being of very fine grain.

Between 154 and 157 feet there seems to have been a bed of very sandy clay or clayey sand, for the sample sent leaves when washed a large residue of sand, which consists almost entirely of quartz-grains, rounded or subangular, partly very small and partly of larger but even-sized grains, with only a few pieces of calcite, which may be worn shell-fragments. No Foraminifera could be seen. Another sample from about 165 feet is a similar dark-grey sandy clay, but between that and 167 feet there seems to have been a bed containing small fragments of stone. The sample yielded a large residue of sand, consisting mainly of subangular quartz-grains varying in size from the finest sand to grains of more than a millimetre in diameter; in this sand were some fragments of calcite,

[1] The apparent discrepancy between 400 and 412 feet is due to the fact that the Contractor bored an additional depth of 12 feet at his own cost.

many pieces of shell, and many fragments of dark-grey, compact, fine-grained siliceous grit, one of which was 7 mm. across; there were also a few black grains which may be glauconite.

The next sample from between 167 and 180 feet is also a very sandy clay, but the sand grains are less unequal in size. It also contained several small fragments of the same dark siliceous rock, but these have probably come from above and have been forced into the sample by the boring tool.

At 207 feet there is stiff but still somewhat sandy clay. At 219 feet they struck a spring of water which rose to within 12 feet of the surface, but there was no bed of rock, and the sample sent from that depth is an ordinary clay with some shell-fragments, but less sandy matter than in that from 207 feet. The water must have been flowing down an open crack of some kind, possibly the plane of a fault, but it was easily shut out and the boring was continued. A sample from 220 feet was a fine rather sandy clay with many thin friable fragments of nacreous Ammonite shells.

A sample from 248 feet is a fine clean clay with little sand and of a dark-grey colour; 20 feet lower, at 268 feet, the sample shows a mixture of two different clays, one clean and dark grey, the other a light-grey finely granular marl or calcareous clay. The material was stated to be very soft and to be of the same consistency for a thickness of 2½ feet, but there must have been two distinct beds, or at any rate a band of marl. When a piece of the latter was washed, it would not wholly break down and very little mud could be washed out of it, the residue consisting of hard angular fragments of marl with a few black grains and minute scales of mica; there were no quartz-grains and no Foraminifera, but a few fragments of shell. A sample from a little lower down (272 feet) is a stiff dark-grey clay full of pieces of crushed Ammonite shells.

The sample from 300 feet is specially interesting, because it contains several specimens of an *Aporrhais* or *Harpagodes*, one of which is fairly perfect though flattened out. It has been examined by Mr. R. B. Newton, of the British Museum, who told me that it closely resembled the *Ap. intermedius* [*sic*] of Piette from the Upper Kimeridgian or Virgulian of the Haute Marne.[1] Having also myself compared the specimen with Piette's figures, I think there can be no doubt that the fossil is *Ap. intermedia*, for not only is it of about the same size and carries four keels which are prolonged into digitations of the expanded wing, but the first whorl of the spire has the same shell-structure of vertical ribs crossed by raised spiral striæ, so that it cannot be the young of *Harpagodes oceani*, though it appears to belong to the genus *Harpagodes* rather than to *Aporrhais*. This species has not previously been recorded from England, and is important stratigraphically because it is only known in the Virgulian, and consequently it indicates that the boring at 300 feet is still in the Virgulian or upper division of the stage.

At 304 feet a sample showed fine sandy clay with many fragments of crushed bivalve shells, among which I recognize a piece of

[1] Mém. Soc. Linn. Normandie, vol. xvi, p. 140, pl. ix, figs. 15–17, 1872.

Cardium striatulum, Sow. With the sample was a piece of flint, and the foreman in charge reported that the tool had passed through a layer of stone. If the flint was supposed to be a sample of the layer of stone, it is obvious that there was no such layer and that the flint had fallen down the bore from the surface. This illustrates how mistaken records of stone layers may get into contractors' accounts of borings.

A sample from 314 feet is a stiff grey clay with little or no sand and does not contain any recognizable fossils. The next sample was from 355 feet and is a somewhat shaly clay of a medium-grey tint; it contains a few fragments of small shells.

No more samples were sent till a depth of 400 feet was reached, the statement then being that the clay had continued to be similar to that sent from 355 feet, but the sample from 400 feet was different, being a compact homogeneous dark-grey clay, cutting like cheese, as if there was much organic matter in the material. At 412 feet the clay was again different, being lighter in colour, not of a cheesy texture, but full of small shell-fragments.

From the facts above recorded I think we may conclude that the upper (Virgulian) division extends to at least a depth of 304 feet, and as about 34 feet must be added at the top the total thickness of this division must be at least 338 feet, and probably a few feet more. The clays at and below 350 feet in the boring probably belong to the Pterocerian or Lower Kimeridge, and the question is how much more of the lower division is likely to exist in this part of Wiltshire. I can only see one way of attempting to solve this question, and that is to assume that the proportional thicknesses of the upper and lower divisions are the same as those of the two divisions in Dorset. In 1880 Blake published a diagram drawn to scale of the relative thicknesses of the several parts of the Kimeridge Clay at Kimeridge.[1] This showed a total of 1,000 feet, and assigned a thickness of about 420 feet to the lower division. Strahan, however, in discussing the thickness of the Upper Kimeridge,[2] took the boundary-line between it and the Portland Sands 100 feet higher than Blake did, which makes the total 1,100 feet and the thickness of the Virgulian about 680 feet. Hence in Dorset the latter forms nearly three-fifths of the whole stage. If, therefore, the proportions are the same in South Wilts, and if we assume the Virgulian to be 340 feet thick at Marston, then the thickness of the Pterocerian will be 205 feet and the total 545 feet.

The importance of this boring is that it has proved the thickness of the Kimeridge Clay near Devizes to be more than 446 feet, and has afforded a basis for making a rough calculation of the probable total thickness of the Clay in that district. It is a great pity that no fund exists from which assistance could be obtained for continuing trial borings of this kind, so that some definite result should be obtained, and the expense incurred by the owner of the property should not be entirely wasted.

[1] Quart. Journ. Geol. Soc., vol. xxxvi, p. 197, 1880.
[2] *Geology of the Isle of Purbeck, etc.* (Mem. Geol. Surv.), 1898, p. 52.

V.—The Zone of *Offaster pilula* in the South English Chalk.

By R. M. Brydone, B.A., F.G.S.

(*Continued from p. 411.*)

III. Dorset.

THERE are three exposures of the horizon of the zone of *O. pilula* on the Dorset coast—at Ballard Head, Arish Mell, and Middle Bottom. Dr. Rowe's description of the Ballard Head section is so unattractive, and the section itself so inconvenient for access and study, that I put it aside to be attempted only if I had time to spare after working out the others, which has not yet happened. Of the other two, that at (or rather under) Middle Bottom is so much the better that I take it first.

A. *Middle Bottom (between White Nothe and Lulworth).*

As is well known from Dr. Rowe's works,[1] the bay at the head of which is Middle Bottom provides a section in chalk lying above the zone of *Marsupites* and having an accessible thickness of about 200 feet, the point at which the highest beds are accessible being under Middle Bottom itself. At this point the beds are apparently flat in all directions, and I did not notice anything about them which I could reconcile with Dr. Rowe's description of them as "riven and shattered in every direction". For some distance westwards from the recess under Middle Bottom the beds seem to continue flat, but an easterly dip (apparently only a component of a stronger S.S.E. dip) then sets in and brings up the beds below in regular succession. The sequence measured was as follows :—

Highest Flint Seam in Reach in the Recess under Middle Bottom.

		ft.	in.	ft.	in.
Zone of *A. quadratus*.	Chalk	8	0		
	Strong flint seam (apparently the one mentioned by Dr. Rowe).				
	Chalk with one *A. quadratus* . . .	4	0		
	Weak flint seam.				
	Chalk	30	0		
	Strong yellowish marl seam.				
	Chalk	2	6		
	Marl seam.				
	Chalk	12	0		
	Parting probably representing a marl seam.				
	Chalk	3	0		
	Flint seam.				
	Chalk	1	0		
	Carried forward . .			60	6

[1] *Coast Sections*, II, pp. 11–13.

			ft.	in.	ft.	in.
		Brought forward			60	6
Zone of *O. pilula*.	Subzone of abundant *O. pilula*.	Upper belt of *O. pilula*.	Strong marl seam, very yellow.			
			Chalk with *O. pilula* of exceptional size	1	6	
			Flint seam.			
			Chalk with large *O. pilula*	1	6	
			Marl seam.			
			Chalk with *O. pilula*	18	0	
		Cinctus belt.	Marl seam.			
			Chalk without marl seams. No *O. pilula* observed	48	0	
		Lower belt of *O. pilula*.	Chalk with *O. pilula*, stretching 5 feet above and 10 feet below a parting. No marl seams or definite flint seams	15	0	
						84	0
	Subzone of *E. scutatus*, var. *depressus*.		Strong flint seam.			
			Chalk	16	0	
			Weak marl seam.			
			Chalk	1	0	
			Strong marl seam.			
			Chalk	27	0	
			Indications of a marl seam.			
			Chalk with perhaps a slide plane at its base	8	6	
						52	6
	Zone of *Marsupites*.		Chalk, very confused and doubtful, perhaps bounded both above and below by slide planes	10	0	
			Chalk	9	0	
			Flinty chalk, yielding *Marsupites*	2	0	
			Chalk	6	6	
			Flint tabular.			
			Chalk with *Marsupites* in lower part	6	0	
						33	6
	Uintacrinus band.		Marl seam and parting.			
			Chalk with *Uintacrinus* at base			63	0
						293	6
			Marl seam and parting.				

The subzone of abundant *O. pilula* is easily recognizable here in its broad features and capable of definite measurement. Closer search than I had time to make would probably enable more of its minor features to be supplied, seeing how closely the lithological and palæontological details at its top coincide with those noted in the same position in Hants, Sussex, and the Isle of Wight. It might also be possible to identify some of the characteristics of the subzone of *Echinocorys scutatus*, var. *depressus*, although the section becomes very unfavourable by the time this horizon is reached. I have taken as the boundary between my zones of *O. pilula* and *Marsupites* the level at which, calculating from the lower boundary of his *Marsupites* band, which can be identified with practical certainty, Dr. Rowe found his highest plate of *Marsupites*. My own finds of *Marsupites* did not carry it outside these limits.

The thickness Dr. Rowe assigns by measurement to the combined zones of *O. pilula* and *A. quadratus* is 204 feet. My corresponding measurement is 189 feet, a very near agreement under the circumstances.

All the marl seams which were noticed have been recorded in the above section. There are in addition a few partings, all of which suggest that they have opened along thin marl seams, the marl of which has been washed away or bleached beyond recognition. But even crediting all these partings as actual marl seams, the paucity of marl seams is very striking when their abundance in the Sussex and Isle of Wight sections is considered.

I did not observe evidence of sliding along the parting which marks the base of the zone of *Marsupites*. In the upper part of the cliff the parting appeared to correspond with the bedding and to be an opening along a marl seam, in which case sliding, if it took place, would leave no clear evidence. When the parting left this marl seam close to the foot of the cliff and curved across the flint seams it did not seem to shift them, as must be the case if there had been sliding along it.

On the east side of the recess under Middle Bottom the cliff line runs out to high-water mark and then turns again east and the beds oscillate slightly without any effective dip for a considerable distance; a further 6 feet of chalk becomes thus measurable, making a measured total of 67 feet of *quadratus* chalk. The westward dip which then sets in and increases rapidly gives a downward section which is practically undisturbed down to the top beds of the zone of *O. pilula*, and these beds agree exactly in thickness with the corresponding beds on the other side of the syncline. Beyond this point the chalk becomes almost immediately too disturbed for reliable measurement.

I am strongly disposed to think that if there is any actual dislocation in this neighbourhood corresponding to the Purbeck fault, it is not a fault but is dissipated into one or more slides along the highly inclined bedding planes of the chalk between the zones of *A. quadratus* and *M. cor-anguinum*, the precise plane or planes of sliding being determined by the lines of weakness offered by marl seams. There are several wide partings at beach level, and one or two at any rate seemed to correspond with marl seams on the other side of Middle Bottom.

B. *Arish Mell.*

This is a most disappointing locality, for it might fairly be hoped that its two sides would between them give a complete section of the zones of *O. pilula* and *A. quadratus*, whereas they do not give a complete recognizable section of either. The accompanying map will aid identification of the various points referred to in the description; the outline given for the base of the cliff is intended to represent beach level under summer conditions.

1. *East side.*—This is another case in which Dr. Rowe does not give any reliable clue for re-identifying the zonal boundaries he adopted. The following section will serve the same purpose as the Scratchells Bay section, of giving subsequent explorers the use of my finds. The crushed flint seam close to the top of the *Uintacrinus* band is easily recognized, and most of the other points can be individually identified.

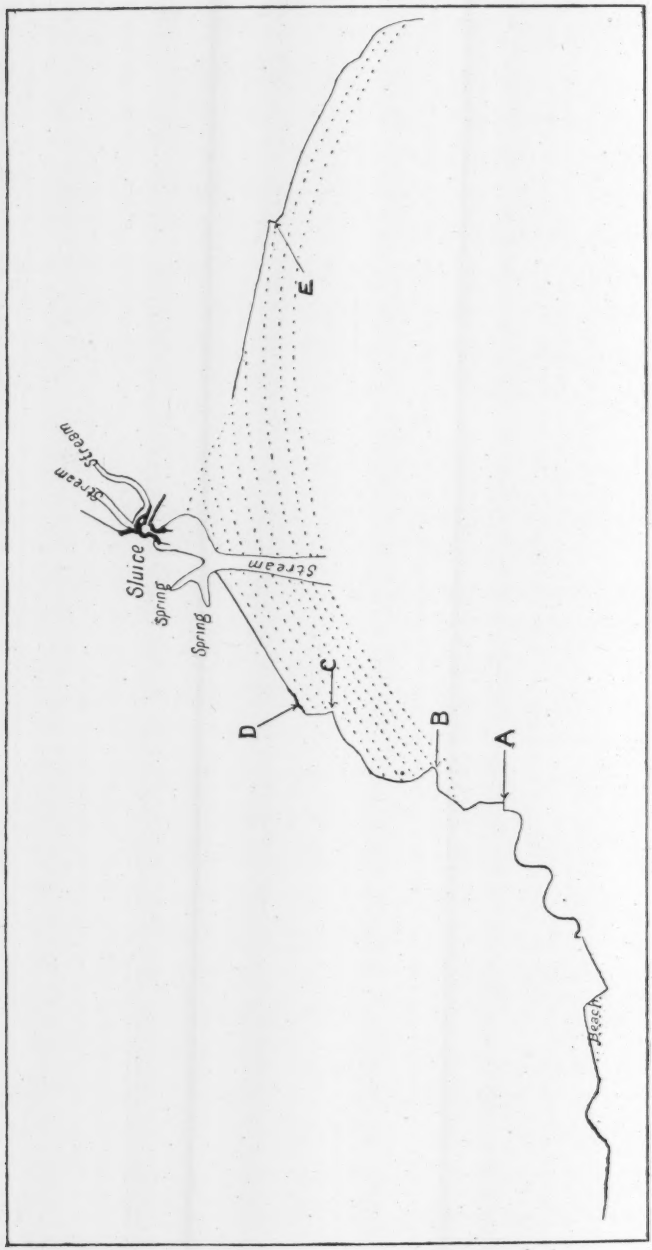


Fig. 1. Ground-plan of cliffs and banks in Arish Mell.

RUBBLY CHALK NEARLY ALL RECONSTRUCTED.

		ft.	in.	ft.	in.
Zone of *O. pilula* (incomplete). — Subzone of abundant *O. pilula*.	Strong marl seam in recess.				
	Chalk with three marl seams, embracing the sharp corner E	16	6		
	Marl seam.				
	Chalk with *O. pilula* and three marl seams, embracing the blunt corner, the lower part strongly veined and honeycombed with calcite	7	9		
				24	3
Subzone of *E. scutatus*, var. *depressus*.	Marl seam wide open.				
	Chalk with three marl seams, one of them open	16	6		
	Marl seam.				
	Chalk	14	6		
	Marl seam cut by slide plane 3 feet above beach.				
	Chalk with one marl seam	12	6		
	Thick marl seam.				
	Chalk	1	0		
	Marl seam.				
	Chalk	6	3		
				50	9
Zone of *Marsupites*.	Flint seam.				
	Chalk with *Marsupites* in highest bed	14	6		
	Very thick marl seam cut by slide plane about 4 feet above beach.				
	Chalk with four marl seams and *Marsupites* in lowest bed	14	6		
	Flint seam.				
	Chalk without *Marsupites* or *Uintacrinus*	3	6		
				32	6
Uintacrinus band.	Marl seam.				
	Chalk without *Uintacrinus* or *Marsupites*	2	6		
	Flint seam.				
	Chalk with *Uintacrinus*	1	6		
	Thick seam of crushed flint cut by slide plane about 8 feet above beach.				
	Chalk	1	0		
	Marl seam.				
	Chalk	16	3		
	Marl seam.				
	Chalk with *Uintacrinus* brachials	6	6		
				27	9
	Marl seam.				

The boundaries taken for the zone of *Marsupites* and the *Uintacrinus* band are of course tentative; the combined thickness of 60 feet assigned to them is obviously a minimum, and may prove to be considerably within the mark. The marl seam taken as the base of the *Uintacrinus* band is the last in descending order for some way; there are two, one thin and one thick, close together a little west of the rain-water gully and one a little beyond it, and then the *cor-anguinum* chalk finally asserts its usual marlless character. The resemblance between this sequence and the corresponding one at Scratchells Bay is striking.

It will be seen that 51 feet above the highest point to which I have traced *Marsupites* an unmistakable representative of the subzone of abundant *O. pilula* makes its appearance, at least six

specimens of *O. pilula* having been observed in a thickness of 7 feet of almost vertical chalk of most unpromising character. Above this point there is only about 22 feet of chalk *in situ*, and it is very unlikely that any representative of the upper belt of *O. pilula* will be identified on this side of the bay. A specimen of *Bourgueticrinus* Form 5 was found a few feet below the belt with *O. pilula*, a normal position for it.

2. *West side.*—The west side of Arish Mell, strictly speaking, runs from the stream to the corner A, at which the vertical chalk comes to an end; but each of the three small sloping promontories immediately succeeding this corner contributes a little more to the thickness of chalk passed over, and they are therefore included.

It will be seen that from the corner A northwards the outline divides itself naturally into three bays. The first runs up to a little above the lowest beach level at corner B; the second runs up to approximately high-water mark at corner C, and its sides are more or less wave-beaten the whole way; and the third runs in a practically straight line to an angle which marks, broadly speaking, the end of the west side of Arish Mell, and thence again in a practically straight line to the stream. About 10 feet east of this angle in the third bay there is a low cascade (D) leading up to a deep hole some 4 feet above the beach level. In winter a stream breaks out either from this hole, running down the cascade, or at the foot of the cascade. The cascade forms an excellent landmark, and starting from a flint seam which crosses the cascade just below its top, and is the highest that can be definitely identified, I measured the following section seaward:—

	ft.	in.
Chalk.	11	6
Flint seam lining a south face extending west from the cascade.		
Chalk with *A. quadratus* at top	4	0
String of large flints.		
Chalk.	28	0
Last flint seam north of angle C.		
Chalk without flints embracing angle C	8	6
Flint seam.		
Chalk.	74	0
Stringy marl seam.		
Chalk.	16	6
Thick marl seam.		
Chalk forming ridge at angle B	2	6
Thick marl seam.		
Chalk.	2	6
Strong parting.		
Chalk.	8	0
Marl seam.		
Chalk.	14	6
Flint seam crossing recess.		
Chalk with giant ossicle of *Metopaster Parkinsoni* . .	6	6
Flint seam at end of clean chalk.		
Chalk.	17	9
Strong marl seam.		
Chalk.	1	6
Marl seam.		
Carried forward . .	195	9

	ft.	in.
Brought forward . .	195	9
Chalk.	2	0
Marl seam.		
Chalk.	16	9
Marl seam.		
Chalk.	2	9
Marl seam passing just south of angle A.		
Chalk with three marl seams	16	8
Marl seam.		
Chalk with *Terebratulina Rowei*, presumably in subzone of abundant *O. pilula*	7	0
Marl seam.		
Chalk with three marl seams	22	0
Marl seam.		
Chalk, perhaps basement bed of subzone of abundant *O. pilula*	1	0
Marl seam.		
Chalk with *E. scutatus*, var. *depressus*, and rectangular *Crateraster quinqueloba*, forming strongly marked face in the third promontory	6	0
Marl seam.		
Chalk with one marl seam	3	8
Marl seam.		
Chalk.	16	6
Marl seam.		
Chalk to extreme foot of third promontory	9	0
	299	1

My starting-point was probably in *quadratus* chalk, as I found a specimen of *A. quadratus* about 12 feet below it on my first visit. The specimen was partly exposed by weathering, and the granulations on it were plainly visible to the naked eye. I exposed its full length and left it there as a landmark, in the hope that it would escape the mere curiosity hunter, and it was still there at my latest visit. For a distance of about 180 feet the chalk was more or less capable of examination, and it could be said with fair certainty that the zone of *O. pilula* had not been reached, though the giant ossicle of *Metopaster Parkinsoni* found in the last few feet hinted at the approach of that zone. Beyond this point the cliff was vertical and wholly obscured and the foreshore little better, and I reached the corner A without seeing any sign of the zone of *O. pilula*. In the promontories west of corner A I was able to identify fairly satisfactorily both the subzone of abundant *O. pilula* (apparently the lower belt of *O. pilula*) and the subzone of *E. scutatus*, var. *depressus*. The individual beds were not at all easy to follow, but those in which I detected the fauna of the subzone of abundant *O. pilula* seemed to pass just south of corner A, so that the upper boundary of this subzone (and of the zone of *O. pilula*) probably passes through the wholly obscured part of the Arish Mell cliff.

Beyond the third promontory the cliff is cut sharply back into the subzone of abundant *O. pilula*, probably as far as the middle belt and possibly at one point into the upper belt of *O. pilula*. The surface is so irregular and the beds so much affected by compression and probable faulting that I could not satisfy myself that they could be followed accurately enough for more positive identification, or for any

attempt at measuring the thickness down to the zone of *Marsupites* at the west end of Cockpit Head.

Returning to my starting-point, the cascade, it is pretty clear that up to the angle just west of it the cliff is wholly composed of chalk *in situ*. But at this angle the upper part of the cliff at once begins to bear a rubbly appearance, which at the cascade has extended some way down the cliff, and within 20 feet west of the cascade the cliff, now more a bank than a cliff in the ordinary sense, becomes definitely alluvial almost to the bottom. There is chalk washed clean at its foot all the way to the stream, but even close to the cascade this chalk had a very boulder-like appearance, and for the greater part of the way it seems clearly to be composed of loose blocks in an alluvial setting. Certainly there is no chalk between the cascade and the stream which looks likely to be *in situ*. Much of the chalk above the cascade and between it and the stream is noticeably softer than any chalk in Arish Mell which is undoubtedly *in situ*.

I find it difficult to reconcile this state of things with Dr. Rowe's description. In the first place we seem to be largely at variance as to the thickness of his *quadratus* zone. His description does not afford any means of accurately identifying the point at which he placed its upper boundary, but from a careful study of his plate VI on the ground it appears to be just about the cascade. This is confirmed by the cascade being as nearly as possible 182 feet from the stream where it cuts the line of the bay. (Dr. Rowe speaks of his starting-point as being about 182 feet from the 'sluice', but he must have intended to write 'stream', for the sluice is much more than 182 feet from any point that can be reconciled with the indications given.) It is therefore probable that we adopted practically the same starting-point, but Dr. Rowe gives a thickness of 354 feet for his *quadratus* zone, while I find that 260 feet takes me well into the subzone of *E. scutatus*, var. *depressus*. Even allowing for the rest of this subzone a further 45 feet, which is almost the full thickness of the subzone on the opposite side of Arish Mell, I only get 305 feet for the combined zones of *A. quadratus* and *O. pilula*, the equivalent of Dr. Rowe's *quadratus* zone. This shows a discrepancy of about 50 feet, which is very considerable for a piece of measuring of which the greater part is quite straightforward.

Another point of difficulty lies in Dr. Rowe's account of *mucronata* chalk at the head of the bay. When I first read this account the impression I derived from it was that it recorded a section reaching 182 feet up into the zone of *B. mucronata*; and I relied upon this impression in discussing[1] the probability of *Magas pumilus* ranging down to the base of that zone. Since familiarizing myself with the locality I have read Dr. Rowe's account again very carefully to see whether I had overlooked some other construction which would harmonize better with my own experience, but I am satisfied that I put the natural interpretation on Dr. Rowe's account. He states (p. 29) that there are "about 182 feet of the *B. mucronata* chalk exposed". Similar expressions occurring in abundance throughout his works refer

[1] *The Stratigraphy of the Chalk of Hants*, p. 9.

invariably to thickness of chalk, not length of exposure; and though it is possible that the phrase is here intended to refer to length of exposure, not thickness of chalk, that theory can hardly be reconciled with the contrast he draws (p. 28) between *M. pumilus* found "close to the sluice" and a form of *Echinocorys* found "near the base of the zone". The point is one of some importance, for if the chalk exposed is *in situ* right up to the stream the strike corresponds so nearly with the direction of the bank between the cascade and the stream that not more than 30 feet of chalk at the outside can be brought in in this distance. A specimen of *M. pumilus* found even at the very edge of the stream would then occur practically at the base of the zone, which is completely at variance with all my experience elsewhere; even the 150 feet of *mucronata* chalk in Whitecliff Bay, and the 196 feet in Scratchells Bay have only yet yielded me one specimen each. But if this chalk is not *in situ*, then the occurrence of *M. pumilus* in it is immaterial in considering the downward range of that fossil. Further, if there is no *mucronata* chalk *in situ* at the foot of the cliff Barrois' reference of the chalk of the west side of Arish Mell to his zone of *Marsupites* is not open to the criticism Dr. Rowe levels at it; for it is abundantly clear that Barrois' zone of *Marsupites* embraced the greater part, probably the whole, of the old zone of *A. quadratus*.

(*To be concluded in the November Number.*)

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, AUSTRALIA, AUGUST, 1914.

I.—Address to the Geological Section by Professor Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S. (President of Section C).

(*Concluded from the September Number, p. 418.*)

TO attempt a discussion of the explanations offered to account for the great Upper Palæozoic glaciation would lead us far from the present theme. The question is raised merely to show that the phenomena are not consistent with the supposed movement of a solid shell over a solid core assisted by an intermediate molten lubricant. Geologists may be compelled to hand back the theory of a molten substratum to the mathematicians and physicists for further repair; but it does not necessarily follow that a foundation theory is unsound merely because it has been overloaded beyond its comprehensive strength.

The extraordinarily great distances between the areas that show signs of glaciation in Permo-Carboniferous times form a serious stumbling-block to most of the explanations which have hitherto been offered. One is almost tempted in despair even to ask if it is not possible that these fragments of the old Gondwana continent are now more widely separated from one another than they were in Upper Palæozoic times. It is a bold suggestion indeed that one can safely put aside as absurd in geomorphology. There is nothing else apparently left for us but the assumption of a general refrigeration.

The idea of the greater inequalities of the globe being in approximately static equilibrium has been recognized for many years: it was expressed by Babbage and Herschel; it was included in Archdeacon Pratt's theory of compensation; and it was accepted by Fisher as one of the fundamental facts on which his theory of mountain structure rested. But in 1889 Captain C. E. Dutton presented the idea "in a modified form, in a new dress, and in greater detail"; he gave the idea orthodox baptism and a name, which seems to be necessary for the

respectable life of any scientific theory. "For the condition of equilibrium of figure, to which gravitation tends to reduce a planetary body, irrespective of whether it be homogeneous or not," Dutton[1] proposed "the name *isostasy*". The corresponding adjective would be isostatic—the state of balance between the ups and downs on the Earth.

For a long time geologists were forced to content themselves with the conclusion that the folding of strata is the result of the crust collapsing on a cooling and shrinking core; but Fisher pointed out that the amount of radial shrinking could not account even for the present great surface inequalities of the lithosphere, without regard to the enormous lateral shortening indicated by the folds in great mountain regions, some of which, like the Himalayan folds, were formed at a late date in the Earth's history, folds which in date and direction have no genetic relationship to G. H. Darwin's primitive wrinkles. Then, besides the folding and plication of the crust in some areas, we have to account for the undoubted stretching which it has suffered in other places, stretching of a kind indicated by faults so common that they are generally known as normal faults. It has been estimated by Claypole that the folding of the Appalachian Range resulted in a horizontal compression of the strata to a belt less than 65 per cent of the original breadth. According to Heim the diameter of the northern zone of the Central Alps is not more than half the original extension of the strata when they were laid down in horizontal sheets. De la Beche, in his memoir on Devon and Cornwall, which anticipated many problems of more than local interest, pointed out that, if the inclined and folded strata were flattened out again, they would cover far more ground than that to which they are now restricted on the geological map. Thus, according to Dutton, Fisher, and others, the mere contraction of the cooling globe is insufficient to account for our great rock-folds, especially great folds like those of the Alps and the Himalayas, which have been produced in quite late geological times. It is possible that this conclusion is in the main true; but in coming to this conclusion we must give due value to the number of patches which have been let into the old crustal envelope—masses of igneous rock, mineral veins, and hydrated products which have been formed in areas of temporary stretching, and have remained as permanent additions to the crust, increasing the size and bagginess of the old coat, which, since the discovery of radium, is now regarded as much older than was formerly imagined by non-geological members of the scientific world.

The peculiar nature of rock-folds presents also an obstacle no less formidable from a qualitative point of view. If the skin were merely collapsing on its shrinking core we should expect wrinkles in all directions; yet we find great folded areas like the Himalayas stretching continuously for 1,400 miles, with signs of a persistently directed overthrust from the north; or we have folded masses like the Appalachians of a similar order of magnitude stretching from Maine to Georgia, with an unmistakable compression in a north-west to south-east direction. The simple hypothesis of a collapsing crust is thus "quantitatively insufficient", according to Dutton, though this is still doubtful, and it is "qualitatively inapplicable", which is highly probable.

In addition to the facts that rock-folds are maintained over such great distances and that later folds are sometimes found to be superimposed on older ones, geologists have to account for the conditions which permit of the gradual accumulation of enormous thicknesses of strata without corresponding rise of the surface of deposition.

On the other hand, too, in folded regions there are exposures of beds superimposed on one another with a total thickness of many miles more than the height of any known mountain, and one is driven again to conclude that uplift has proceeded *pari passu* with the removal of the load through the erosive work of atmospheric agents.

It does not necessarily follow that these two processes are the direct result of loading in one case and of relief in the other; for slow subsidence gives rise

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to the conditions that favour deposition and the uplifting of a range results in the increased energy of eroding streams.

Thus there was a natural desire to see if Dutton's theory agreed with the variations of gravity. If the ups and downs are balanced, the apparently large mass of a mountain range ought to be compensated by lightness of material in and below it. Dutton was aware of the fact that this was approximately true regarding the great continental plateau and oceanic depressions; but he imagined that the balance was delicate enough to show up in a small hill-range of 3,000 to 5,000 feet.

The data required to test this theory accumulated during the triangulation of the United States, have been made the subject of an elaborate analysis by J. F. Hayford and W. Bowie.[1] They find that, by adopting the hypothesis of isostatic compensation, the differences between the observed and computed deflections of the vertical caused by topographical inequalities are reduced to less than one-tenth of the mean values which they would have if no isostatic compensation existed. According to the hypothesis adopted, the inequalities of gravity are assumed to die out at some uniform depth, called the depth of compensation, below the mean sea-level. The columns of crust material standing above this horizon vary in length according to the topography, being relatively long in highlands and relatively short under the ocean. The shorter columns are supposed to be composed of denser material, so that the product of the length of each column by its mean density would be the same for all places. It was found that by adopting 122 kilometres as the depth of compensation, the deflection anomalies were most effectually eliminated, but there still remained unexplained residuals or local anomalies of gravity to be accounted for.

Mr. G. K. Gilbert,[2] who was one of the earliest geologists to turn to account Dutton's theory of isostasy, has recently offered a plausible theory to account for these residual discrepancies between the observed deflections and those computed on the assumption of isostatic compensation to a depth of 122 kilometres. An attempt had already been made by Hayford and Bowie to correlate the distribution of anomalies with the main features of the geological map and with local changes in load that have occurred during comparatively recent geological times. For example, they considered the possibility of an increased load in the Lower Mississippi Valley, where there has been in recent times a steady deposition of sediment, and therefore possibly the accumulation of mass slightly in advance of isostatic adjustment. One would expect in such a case that there would be locally shown a slight excess of gravity, but, on the contrary, there is a general prevalence of negative anomalies in this region. In the Appalachian region, on the other hand, where there has been during late geological times continuous erosion, with consequent unloading, one would expect that the gravity values would be lower, as isostatic compensation would naturally lag behind the loss of overburden; this, however, is also not the case, for over a greater part of the Appalachian region the anomalies are of the positive order. Similarly, in the north central region, where there has been since Pleistocene times a removal of a heavy ice-cap, there is still a general prevalence of positive anomalies.

These anomalies must, therefore, remain unexplained by any of the obvious phenomena at the command of the geologist. G. K. Gilbert now suggests that, while it may be true that the product of the length of the unit column by its mean density may be the same, the density variations within the column

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may be such as to give rise to different effects on the pendulum. If, for instance, one considers two columns of the same size and of exactly the same weight, with, in one case, the heavy material at a high level and in the other case with the heavy material at a low level, the centre of gravity of the former column, being nearer the surface, will manifest itself with a greater pull on the pendulum; these columns would be, however, in isostatic adjustment.[1]

Gilbert's hypothesis thus differs slightly from the conception put forth by Hayford and Bowie; for Gilbert assumes that there is still appreciable heterogeneity in the more deep-seated parts of the Earth, while Hayford and Bowie's hypothesis assumes that in the nuclear mass density anomalies have practically disappeared, and that there is below the depth of compensation an adjustment such as would exist in a mass composed of homogeneous concentric shells.

In order to make the Indian observations comparable to those of the United States as a test of the theory of isostasy, Major H. L. Crosthwait[2] has adopted Hayford's system of computation and has applied it to 102 latitude stations and eighteen longitude stations in India. He finds that the unexplained residuals in India are far more pronounced than they are in the United States, or, in other words, it would appear that isostatic conditions are much more nearly realized in America than in India.

The number of observations considered in India is still too small for the formation of a detailed map of anomalies, but the country can be divided into broad areas which show that the mean anomalies are comparable to those of the United States only over the Indian Peninsula, which, being a mass of rock practically undisturbed since early geological times, may be regarded safely as having approached isostatic equilibrium. To the north of the peninsula three districts form a wide band stretching west-north-westwards from Calcutta, with mean residual anomalies of a positive kind, while to the north of this band lies the Himalayan belt, in which there is always a large negative residual.

Colonel Burrard[3] has considered the Himalayan and sub-Himalayan anomalies in a special memoir, and comes to the conclusion that the gravity deficiency is altogether too great to be due to a simple geosynclinal depression filled with light alluvium such as we generally regard the Gangetic trough to be. He suggests that the rapid change in gravity values near the southern margin of the Himalayan mass can be explained only on the assumption of the existence of a deep and narrow rift in the sub-crust parallel to the general Himalayan axis of folding. A single large rift of the kind and size that Colonel Burrard postulates is a feature for which we have no exact parallel; but one must be careful not to be misled by the use of a term which, while conveying a definite mental impression to a mathematician, appears to be incongruous with our geological experience. There may be no such thing as a single large rift filled with light alluvial material, but it is possible that there may still be a series of deep-seated fissures that might afterwards become filled with mineral matter.

With this conception of a rift or a series of rifts, Colonel Burrard is led to reverse the ordinary mechanical conception of Himalayan folding. Instead now of looking upon the folds as due to an overthrust from the north, he regards

[1] It is interesting to note that the idea suggested by G. K. Gilbert in 1913 was partly anticipated by Major H. L. Crosthwait in 1912 (Survey of India, Professional Paper No. 13, p. 5). Major Crosthwait, in discussing the similar gravity anomalies in India, remarks parenthetically: "Assuming the doctrine of isostasy to hold, is it not possible that in any two columns of matter extending from the surface down to the depth of compensation there may be the same mass, and yet that the density may be very differently distributed in the two columns? These two columns, though in isostatic equilibrium, would act differently on the plumb-line owing to the unequal distribution of mass. The drawback to treating this subject by hard and fast mathematical formulæ is that we are introducing into a discussion of the constitution of the earth's crust a uniform method when, in reality, probably no uniformity exists."

[2] Survey of India, Professional Paper No. 13, 1912.

[3] Ibid., No. 12, 1912.

the corrugations to be the result of an under-creep of the sub-crust towards the north. Thus, according to this view, the Himalaya, instead of being pushed over like a gigantic rock-wave breaking on to the Indian *Horst*, is in reality being dragged away from the old peninsula, the depression between being filled up gradually by the Gangetic alluvium. So far as the purely stratigraphical features are concerned, the effect would be approximately the same whether there is a superficial overthrust of the covering strata or whether there is a deep-seated withdrawal of the basement which is well below the level of observation.

Since the Tibetan expedition of ten years ago we have been in possession of definite facts which show that to the north of the central crystalline axis of the Himalaya there lies a great basin of marine sediments forming a fairly complete record from Palæozoic to Tertiary times, representing the sediments which were laid down in the great central Eurasian ocean to which Suess gave the name *Tethys*. We have thus so far been regarding the central crystalline axis of the Himalaya as approximately coincident with the old northern coast-line of Gondwanaland; but, if Colonel Burrard's ideas be correct, the coastline must have been very much further to the south before the Himalayan folding began.

Representing what the Geological Survey of India regards as the orthodox view, Mr. H. H. Hayden [1] has drawn attention to some conclusions which, from our present geological knowledge, appear to be strange and improbable in Colonel Burrard's conclusions, and he also offers alternative explanations for the admitted geodetic facts. Mr. Hayden suggests, for instance, that the depth of isostatic compensation may be quite different under the Himalayan belt from that under the regions to the south. His assumptions, however, in this respect are, as pointed out by Colonel G. P. Lenox Conyngham,[2] at variance with the whole theory of isostasy. Mr. Hayden then suggests that most of the excessive anomalies would disappear if we took into account the low specific gravity of the sub-Himalayan sands and gravels of Upper Tertiary age as well as of the Pleistocene and recent accumulations of similar material filling the Indo-Gangetic depression. It would not be at all inconsistent with our ideas derived from geology to regard the Gangetic trough as some 3 or 4 miles deep near its northern margin, thinning out gradually towards the undisturbed mass of the Indian Peninsula, and Mr. R. D. Oldham,[3] with this view, has also calculated the effect of such a wedge of alluvial material of low specific gravity, coming to the conclusion that the rapid change in deflection, on passing from the Lower Himalaya southward towards the peninsula, can mainly be explained by the deficiency of mass in the alluvium itself.

It is obvious that, before seeking for any unusual cause for the gravity anomalies, we ought to take into account the effect of this large body of alluvium which lies along the southern foot of the range. It is, however, by no means certain that a thick mass of alluvial material, accumulated slowly and saturated with water largely charged with carbonate of lime, would have a specific gravity so appreciably lower than that of the rocks now exposed in the main mass of the Himalaya as to account for the residual anomalies. Some of the apparent deficiency in gravity is due to this body of alluvium, but it will only be after critical examination of the data and more precise computation that we shall be in a position to say if there is still room to entertain Colonel Burrard's very interesting hypothesis.

By bringing together the geological and geodetic results we notice five roughly parallel bands stretching across Northern India. There is (1) a band of abnormal high gravity lying about 150 miles from the foot of the mountains, detected by the plumb-line and pendulum; (2) the great depression filled by the Gangetic alluvium; (3) the continuous band of Tertiary rock, forming the sub-Himalaya, and separated by a great boundary overthrust from (4) the main

[1] Rec. Geol. Surv. Ind., vol. xliii, pt. ii, p. 138, 1913.
[2] Rec. Surv. Ind., vol. v, p. 1.
[3] Proc. Roy. Soc., ser. A, vol. xc, p. 32, 1914.

mass of the Outer and Central Himalaya of old unfossiliferous rock, with the snow-covered crystalline peaks flanked on the north by (5) the Tibetan basin of highly fossiliferous rocks formed in the great Eurasian mediterranean ocean that persisted up to nearly the end of Mesozoic times.

That these leading features in North India can hardly be without genetic relationship one to another is indicated by the geological history of the area. Till nearly the end of the Mesozoic era the line of crystalline, snow-covered peaks now forming the Central Himalaya was not far from the shore-line between Gondwanaland, stretching away to the south, and Tethys, the great Eurasian ocean. Near the end of Mesozoic times there commenced the great outwelling of the Deccan Trap, the remains of which, after geological ages of erosion, still cover an area of 200,000 square miles, with a thickness in places of nearly 5,000 feet. Immediately after the outflow of this body of basic lava, greater in mass than any known eruption of the kind, the ocean flowed into North-West India and projected an arm eastwards to a little beyond the point at which the Ganges now emerges from the hills. Then followed the folding movements that culminated in the present Himalayan Range, the elevation developing first on the Bengal side, and extending rapidly to the north-west until the folds extended in a great arc for some 1,400 miles from south-east to north-west.

New streams developed on the southern face of the now rising mass, and although the arm of the sea that existed in early Tertiary times became choked with silt, the process of subsidence continued, and the gradually subsiding depression at the foot of the hills as fast as it developed became filled with silt, sand, gravel, and boulders in increasing quantities as the hills became mountains and the range finally reached its present dimensions, surpassing in size all other features of the kind on the face of the globe.

Now, it is important to remember that for ages before the great outburst of Deccan Trap occurred there was a continual unloading of Gondwanaland, and a continual consequent overloading of the ocean bed immediately to the north; that this process went on with a gradual rise on one side and a gradual depression on the other; and that somewhere near and parallel to the boundary line the crust must have been undergoing stresses which resulted in strain, and, as I suggest, the development of those fissures that let loose the floods of Deccan Trap and brought to an end the delicate isostatic balance.

During the secular subsidence of the northern shore-line of Gondwanaland, accompanied by the slow accumulation of sediment near the shore and the gradual filing away of the land above sea-level, there must have been a gradual creep of the crust in a northerly direction. Near the west end of the Himalayan arc this movement would be towards the north-west for a part of the time; at the east end the creep would be towards the north-north-east and north-east. Thus there would be a tendency from well back in Palæozoic times up to the end of the Cretaceous period for normal faults—faults of tension—to develop on the land, with a trend varying from W.S.W.–E.N.E. to W.N.W.–E.S.E. across the northern part of Gondwanaland. We know nothing of the evidence now pigeon-holed below the great mantle of Gangetic alluvium, while the records of the Himalayan region have been masked or destroyed by later foldings. But in the stratified rocks lying just south of the southern margin of the great alluvial belt we find a common tendency for faults to strike in this way across the present peninsula of India. These faults have, for instance, marked out the great belt of coal-fields stretching for some 200 miles from east to west in the Damuda Valley. On this, the east side of India, the fractures of tension have a general trend of W.N.W.–E.S.E. We know that these faults are later than the Permian period, but some of them certainly were not much later.

If we now go westwards across the Central Provinces and Central India and into the eastern part of the Bombay Presidency, we find records of this kind still more strikingly preserved; for where the Gondwana rocks, ranging from Permo-Carboniferous to Liassic in age, rest on the much older Vindhyan Series, we find three main series of these faults. One series was developed before Permo-Carboniferous times; another traverses the Lower Gondwanas, which

range up to about the end of Permian times; while the third set affects the younger and Upper Gondwanas of about Rhætic or Liassic age. Although the present topography of the country follows closely the outlines of the geological formations, it is clear from the work of the Geological Survey of India that these outlines were determined in Mesozoic times, and that the movements which formed the latest series of faults were but continuations of those which manifested themselves in Palæozoic times. According to Mr. J. G. Medlicott, the field data showed "that a tendency to yield in general east and west or more clearly north-east and south-west lines existed in this great area from the remote period of the Vindhyan fault".[1] The author of the memoir and map on this area was certainly not suspicious of the ideas of which I am now unburdening my mind; on the contrary, he attempted and, with apologies, failed to reconcile his facts to views then being pushed by the weight of 'authority' in Europe. This was not the last time that facts established in India were found (to use a field geologist's term) unconformably to lie on a basement of geological orthodoxy as determined by authority in Europe. It is important to notice that the series of faults referred to in the central parts of India are not mere local dislocations, but have a general trend for more than 250 miles.

A fault must be younger, naturally, than the strata which it traverses, but how much younger can seldom be determined. Intrusive rocks of known age are thus often more useful in indicating the age of the fissures through which they have been injected, and consequently the dykes which were formed at the time of the eruption of the great Deccan Trap give another clue to the direction of stresses at this critical time, that is, towards the end of the Cretaceous period, when the northerly creep had reached its maximum, just before Gondwanaland was broken up. If, now, we turn to the geological maps of the northern part of Central India, the Central Provinces, and Bengal, we find that the old Vindhyan rocks of the Narbada Valley were injected with hundreds of trap-dykes which show a general W.S.W.–E.N.E. trend, and thus parallel to the normal tension faults, which we know were formed during the periods preceding the outburst of the Deccan Trap. This general trend of faults and basic dykes is indicated on many of the published geological maps of India covering the northern part of the peninsula, including Ball's maps of the Ramgarh and Bokaro Coal-fields[2] and of the Hutar Coal-field,[3] Hughes' Rewa Gondwana basin,[4] Jones' southern coal-fields of the Satpura basin,[5] and Oldham's general map of the Son Valley.[6]

We see, then, that the development of fissures with a general east–west trend in the northern part of Gondwanaland culminated at the end of the Cretaceous period, when they extended down, probably, to the basic magma lying below the crust either in a molten state or in a state that would result in fluxion on the relief of pressure. That the molten material came to the surface in a superheated and liquid condition is shown by the way in which it has spread out in horizontal sheets over such enormous areas. Throughout this great expanse of lava there are no certain signs of volcanic centres, no conical slopes around volcanic necks; and one might travel for more than 400 miles from Poona to Nagpur over sheets of lava which are still practically horizontal. There is nothing exactly like this to be seen elsewhere to-day. The nearest approach to it is among the Hawaiian calderas, where the highly mobile basic lavas also show the characters of superfusion, glowing, according to J. D. Dana,[7] with a white heat, that is, at a temperature not less than about 1,300° C.

Mellard Reade has pointed out that the Earth's crust is under conditions of stress analogous to those of a bent beam, with, at a certain depth, a "level of

[1] Mem. Geol. Surv. Ind., vol. ii, pt. ii, p. 256, 1860.
[2] Ibid., vol. vi, pt. ii.
[3] Ibid., vol. xv.
[4] Ibid., vol. xxi, pt. iii.
[5] Ibid., vol. xxiv.
[6] Ibid., vol. xxxi, pt. i.
[7] *Characteristics of Volcanoes*, 1891, p. 200.

no strain". Above this level there should be a shell of compression, and under it a thicker shell of tension. The idea has been treated mathematically by C. Davison, G. H. Darwin, O. Fisher, and M. P. Rudski, and need not be discussed at present. Professor R. A. Daly has taken advantage of this view concerning the distribution of stresses in the crust to explain the facility for the injection of dykes and batholiths from the liquid, or potentially liquid, gabbroid magma below into the shell of tension.[1] He also shows that the injection of large bodies of basic material into the shell of tension tends on purely mechanical grounds to the formation of a depression or geosyncline. If this be so, are we justified in assuming that the heavy band following the southern margin of the Gangetic geosyncline is a 'range' of such batholiths? The idea is not entirely new; for O. Fisher made the suggestion more than twenty years ago that the abnormal gravity at Kalianpur was due to "some peculiar influence (perhaps of a volcanic neck of basalt)".[2]

Daly's suggestion, however, taken into account with the history of Gondwanaland, may explain the peculiar alignment of the heavy subterranean band, parallel to the Gangetic depression and parallel to the general trend of the peninsular tension-faults and fissures that followed the unloading of Gondwanaland and the heavy loading of the adjoining ocean bed along a band roughly parallel to the present Himalayan folds.

R. S. Woodward objected that isostasy does not seem to meet the requirements of geological continuity, for it tends rapidly towards stable equilibrium, and the crust ought therefore to reach a stage of repose early in geologic time.[3] If the process of denudation and rise, with adjoining deposition and subsidence, occurred on a solid globe, this objection might hold good. But it seems to me that the break-up of Gondwanaland and the tectonic revolutions that followed show how isostasy can defeat itself in the presence of a sub-crustal magma actually molten or ready to liquefy on local relief of pressure. It is possible that the protracted filing off of Gondwanaland brought nearer the surface what was once the local level of no strain and its accompanying shell of tension.

The conditions existing in Northern Gondwanaland before late Mesozoic times must have been similar to those in South-West Scotland before the occurrence of the Tertiary eruptions, for the crust in this region was also torn by stresses in the S.W.–N.E. direction with the formation of a remarkable series of N.W.–S.E. dykes which give the 1 in. geological maps in this region a regularly striped appearance.

There is no section of the Earth's surface which one can point to as being now subjected to exactly the same kind and magnitude of treatment as that to which Gondwanaland was exposed for long ages before the outburst of the Deccan Trap; but possibly the erosion of the Brazilian highlands and the deposition of the silt carried down by the Amazon, with its southern tributaries, and by the more eastern Araguay and Tocantins, may result in similar stresses which, if continued, will develop strains, and open the way for the subjacent magma to approach the surface or even to become extravasated, adding another to the small family of so-called fissure-eruptions.

The value of a generalization can be tested best by its reliability as a basis for prediction. Nothing shows up the shortcomings of our knowledge about the state of affairs below the superficial crust so effectually as our inability to make any useful predictions about earthquakes or volcanic eruptions. For many years to come in this department of science the only worker who will ever establish a claim to be called a prophet will be one in Cicero's sense—"he who guesses well."

[1] R. A. Daly, "Abyssal Igneous Injection as a Causal Condition and as an Effect of Mountain-building": Amer. Journ. Sci., vol. xxii, p. 205, September, 1906.

[2] *Physics of the Earth's Crust*, 2nd ed., 1889, p. 216.

[3] Address to the Section of Mathematics and Astronomy of the Amer. Assoc., 1889. Smithsonian Report, 1890, p. 196.

II.—*Papers read in Section C (Geology), Meeting of British Association, Australia, August, 1914.*

(1) The Permo-Carboniferous Breccia, a Desert Formation.

By H. T. Ferrar, M.A., F.G.S.[1]

DURING the meeting of the Association at Birmingham last year members of this Section had an ample opportunity for visiting the chief exposures of the so-called Permian breccia of the midland counties of England. This deposit may be briefly described as a mass of sandstones and marls with occasional sheets of angular breccia, the latter consisting in a large measure of volcanic rocks, grits, slates, and limestones which can be identified with rocks on the borders of Wales. The organic remains which have been recorded are few, but such as occur are indicative chiefly of terrestrial surfaces.

The origin of the breccia has given rise to many speculations, amongst which may be mentioned—

1. Murchison (1839) regarded it as a volcanic or trappoid breccia marking the position of underground masses of volcanic rocks hidden under a cover of their own fragments.

2. Ramsay (1855) ascribed its origin to the existence of glacial conditions in Permian times.

3. Geikie (1892) says with regard to Scotland that the breccia has evidently accumulated in small lakes or narrow fiords during periods of great and rapid denudation following uplift of the Upper Carboniferous rocks.

4. Bonney (1902) concludes that breccias are usually indicative of continental conditions, but that glaciers are necessary for the transport of the larger boulders.

5. Lapworth (1912) holds that they are the memorials of local Alpine conditions.

In Egypt a chain of fold-mountains forms the watershed between the Nile and the Red Sea, and the mountains are intersected and drained by steep-sided gorges or wadis. The climate is arid with occasional heavy thunderstorms causing temporary torrents, which sweep forward all rock-material loosened during the prevailing dry climate. The wadi beds receive continuously a fresh supply of angular debris shed from the adjacent bare hillsides, and any fragments which may have become rounded or subangular are often shattered before the next flood sweeps them forward another stage on their journey towards a more permanent resting-place, namely, the alluvial plain at the wadi-mouth. Blocks slipping down the bare hillsides become scratched or they may be scratched by mutual impact during a sudden rush of flood-water. Great blocks are often carried fifty or one hundred miles down the wadi channels, and the agency of ice need not be invoked to explain their transport.

The valley fill of most wadis in the Eastern Desert of Egypt is an unconsolidated breccia so similar to the breccia exposed on Ley Hill, near Birmingham, that there is little room for doubt that the two originated under similar climatic conditions.

[1] By permission of the Director-General, Egyptian Survey Department.

(2) Climates and Physical Conditions of the Early Pre-Cambrian. By Professor A. P. Coleman, F.R.S., Toronto.

OUR knowledge of the later Pre-Cambrian permits us to speak of desert conditions in the Keweenawan or Torridonian and of an ice age followed by a cool climate in the Huronian, but little evidence has been given as to earlier climates. Recent work in Canada shows that the Sudbury Series, of Pre-Laurentian age and very much older than the Huronian, includes all types of sediments, often well enough preserved to show cross-bedding, ripple-marks, and annual layers indicating the change of seasons. They must have been formed near the margin of a continent where granites weathered under a cool and moist climate. They seem to be delta materials deposited by great rivers.

The highly metamorphosed sediments of the still older Grenville and Keewatin Series (Lewisian?) have lost their original structures, but the gneisses, quartzites, and marbles must have been clay, sand, and limestone in the beginning, and the graphite may have originated in plants. Land surfaces must have been attacked by water and air to produce these materials, and there is no evidence that the climate was hot. These are the earliest known formations, so that air and water worked in the usual way at the beginning of recorded geological time.

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(3) The Tertiary Brown Coal-beds of Victoria. By H. Herman, B.C.E., M.M.E., F.G.S., Director of the Geological Survey of Victoria.

THE brown coal-beds of Victoria are probably the thickest yet recorded in the world. The more extensive areas are the La Trobe Valley, Alberton, Altona, and Lal Lal. Minor beds are widely distributed.

The geological age has not yet been definitely fixed, except at Altona, where a brown coal-seam 140 feet thick underlies marine Oligocene beds. Flows of basalt overlie the brown coal in places, and underlie it in others. The range in age is probably from Oligocene upwards. Seams outcrop at Narracan, Thorpdale, Dean's March, Morwell, and Boolarra.

Where below the surface, the seams are prospected by boring. In many bores coal of several hundred feet in thickness is shown; one bore had an aggregate thickness of 781 feet of coal in a depth of 1,010 feet. The overburden is from a few feet to 500 feet deep.

In the Alberton area of about 300 square miles and the La Trobe Valley area of 700 square miles there is probably 30,000,000,000 tons of coal. The approximate area at Altona is 200 square miles, with a probable average thickness of 50 feet of coal. At Lal Lal the coal covers 3 square miles with an average thickness of 80 feet.

The geological and geographical distribution of the various brown coal-seams is still being ascertained by boring; the bores are being systematically tested for calorific value, gas production, and by-products. A typical analysis of the brown coal, as freshly mined, is—

	Per cent.
H_2O	53·00
V.H.C.	24·50
F.C.	21·50
Ash	1·00
	100·00

Sulphur	0·7 per cent.
Nitrogen	0·3 per cent.
Calorific value	5500–6000 B.T.U.
Evaporation value	4 lb. water.
Gas per ton	6,500 cubic feet.

Ammonium sulphate per ton (theoretical), 32 lb.

Experimental work has also proved that under proper conditions a firm hard briquette can be produced without the aid of an agglutinant binder. It is suitable also for use in the gas producer, the improvements in which of recent years bid fair to give brown coal an important place in the power-fuels of the world at no distant date.

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(4) The Sedimentary Rocks of South Victoria Land. By F. Debenham, B.A., B.Sc., Geologist to Captain Scott's Last Expedition, 1910–13.

THE topography of the area was first described in brief, showing how the comparatively meagre knowledge of the geology of such a vast region is due largely to its plateau structure, which presents merely an edge of the continent, the interior being completely covered by a thick ice-cap. The systems at present known to occur were then described in order of their age.

1. The Foundation Rocks, a vast complex of gneisses, schists, and crystalline limestones, largely of sedimentary origin, with their axes of folding in a meridional direction. They must at present be referred to Pre-Cambrian age, though a less altered series of slates and quartzites in the Cape Adare region may possibly be younger.

2. The Cambrian of the Beardmore Glacier. The outcrop of this series has not yet been visited, the evidence for its occurrence being derived from moraine blocks. Its probable disposition was sketched, and a possible connexion between the Archæocyathinæ found in these blocks and those found in the Weddell Sea was traced.

3. The Upper Devonian shales of Granite Harbour. This thin bed of shales was formerly supposed to be a part of the Beacon Sandstone Series, with which it is quite conformable, but evidence was brought forward to prove that it is of earlier date, the most important being the occurrence of numerous Devonian fish scales.

4. The Permo-Carboniferous Sandstones. The already well-known Beacon Sandstone was proved to be of this age from the fossils brought back by the last expedition. The series was thoroughly described from three type areas, and its probable limits indicated. An attempt to correlate it with other large Permo-Carboniferous regions in the world was made, having special regard to the Australian examples. The great variations in lithological character in different parts of the series was described, and reasons for them suggested from the stratigraphical relationships, with a sketch of the probable climatic

conditions at the time of deposition drawn chiefly from the internal evidence of the sandstones. The coal-beds associated with the series were described in detail.

5. Recent. A brief description of the only other sedimentary deposits yet found was given, they consisting chiefly of local beds of volcanic tuffs and some moraine deposits.

The paper concluded with a brief sketch of the history of South Victoria Land as compared with that of the South American Quadrant as recorded by their respective sedimentary deposits.

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(5) Victoria Graptolites. By T. S. Hall, M.A., D.Sc., Lecturer in Biology in the University of Melbourne.

THE Silurian and Ordovician graptolite-bearing rocks of Victoria occupy about 20,000 square miles, and over a hundred species have been recorded.

Very little is known of the Silurian. The Ordovician is divided into Upper and Lower, but probably represents a continuous series. The Upper is characterized by the presence of Dicranograptidæ. No zonal work has been done in the field, though collections yielding about fifty recorded species have been made.

Four divisions are recognized in the Lower Ordovician, namely, Darriwillian, Castlemainian, Bendigonian, and Lancefieldian, at the base. There are several subdivisions of these formations. The characters were briefly indicated in the Geological Magazine by the author in 1899. Subsequent work by T. S. Hart, F.G.S., at Daylesford, has confirmed the sequence established. Large collections made by the Survey at many localities have somewhat extended our knowledge of the fauna and its distribution, but without adding any features of great importance.

The Upper Ordovician ranges north from Eastern Victoria for 300 miles into New South Wales. In New Zealand Lancefieldian occurs at Preservation Inlet, and two Castlemaine zones occur as well. It is probable that the Victorian sequence, and not the British, as stated, will be found.

Broadly, the sequence of Australian Graptolites agrees with the European, but in details is closer to that of New York, as Ruedemann has pointed out. The important differences in the range of *Didymograptus bifidus*, *D. caduceus*, *D. nicholsoni*, *Loganograptus*, *Clonograptus rigidus*, and some other genera and species negative the idea that graptolite zones are world-wide, and as no one believes that all genera and species originated in one locality and radiated thence this is what we should expect.

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(6) On the Term Permo-Carboniferous and on the Correlation of that System. By W. S. Dun and T. W. Edgeworth David.

THE term Permo-Carboniferous was originally applied to certain formations in Queensland which on stratigraphical evidence were at the time considered to belong to one and the same general system. At the time it was considered that a series of strata at

Gympie, which contained an assemblage of fossils of distinct Permian affinities, were stratigraphically below another set of strata known as the Star Beds. The latter contain among other fossils *Phillipsia*, *Lepidodendron Australe*, and *Aneimites*, all typical Carboniferous fossils in Australia, and the first mostly of Devonian age. Accordingly these formations were grouped together under the term Permo-Carboniferous, and the name has subsequently been widely used. It has now been proved that, so far as Queensland is concerned, the name has been given in error. The Gympie Beds are stratigraphically above the Star Beds, not below as was originally supposed. Nowhere in Australia or Tasmania has a single trilobite or *Lepidodendron* ever been found in our Carboniferous rocks proper. In the absence of a zoning of these Carboniferous rocks it is impossible to say what exactly are its equivalents in other parts of the world. If it is wholly Lower Carboniferous, as some suppose, there may be some justification for the retention of the term Permo-Carboniferous, but if its fauna and flora ascend to Upper Carboniferous, then it is suggested that there is much to be said in favour of using the term Permian instead. In Russia *Schizodus* occurs in numbers beneath the whole, not only of the *Glossopteris* beds, but of the *Gangamopteris* beds also of the Dwina system. In South America the Lower Rocks of the Santa Catharina system appear to be more Permian than anything else, and the occurrence of the strong swimming reptile *Mesosaurus* both in the Permo-Carboniferous rocks of South America and of South Africa suggests that the South African Permo-Carboniferous rocks also may be chiefly Permian.

In the correlation of the Australian Permo-Carboniferous formations, special emphasis is laid on the Indian facies of the West Australian Permo-Carboniferous fauna.

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(7) The Evolution of Victoria during the Kainozoic Period. By D. J. Mahony, M.Sc., F.G.S., Geological Survey of Victoria.

THE Kainozoic period in Victoria is characterized by great earth movements accompanied by volcanic action; the present topography is a consequent development.

The central highland area (Palæozoic rocks) extends from the eastern boundary of the state westwards to the Grampians; to the north and south it is bounded by low-lying plains (Kainozoic strata), which gradually broaden towards the west until they merge into one another. To the south Wilson's Promontory (granite), South Gippsland (Mesozoic), and the Cape Otway district (Mesozoic) rise above the plains. The highland area is essentially a dissected peneplain sinking from some 5,000 feet above sea-level in Gippsland to 900 feet at its western extremity; the only Kainozoic rocks upon it are river-gravels, lake-deposits, and volcanics.

The plains (500 feet) are areas of Kainozoic sedimentation with some interbedded and overlying volcanic rocks; the sedimentary series consists of lacustrine or estuarine beds, followed by marine clays (Oligocene), foraminiferal limestones (Miocene), and sandstones (Pliocene). These beds rest upon Palæozoic or Mesozoic rocks.

On the surface of the ancient peneplain, 5,000 feet above sea-level, (?) Miocene plant-remains and river-gravels are preserved beneath basalt at Dargo High Plains. This indicates a long pre-Miocene period of quiescence followed by a great uplift. This area has not been submerged during the Kainozoic.

The nature of the Kainozoic Series indicates that, outside the highland area, a gradual subsidence of considerable magnitude (Oligocene and Miocene), accompanied by volcanic outbreaks (Miocene), was followed by re-elevation to a maximum of about 900 feet above sea-level (Pliocene or post-Pliocene). There is evidence to show that the movements were not uniform in direction, though the net result was depression or elevation. Bass Strait is a recently sunken area in which equilibrium has not yet been established.

The nearly horizontal position of the Kainozoic rocks indicates that the movements were vertical; and there are, moreover, examples of Kainozoic faults in which the differential movement amounts to 900 feet.

The volcanic rocks are basaltic except for sporadic occurrences of alkali rocks in Eastern, Central, and Western Victoria.

The Older Basalts are most abundant to the east of Melbourne. Some remnants occur on the ancient peneplain 3,000 feet above the present streams, but the most extensive areas are at lower levels in South Gippsland. At Flinders the Older Basalt underlies marine Miocene, and has been proved by boring to be over 1,300 feet thick, and to extend from sea-level to that depth. In some instances the age can be conclusively proved, but in others the evidence is poor. These basalts are associated with the first great period of earth movements.

The Newer Basalts are most extensively developed in the western district, where their northern boundary is not far from the 500 ft. contour; here they overlie marine Kainozoics. Large areas are also found on the plateau west of Kilmore and along its northern flanks. The Newer Basalts are never covered by marine deposits, except recent accumulations near the coast, their surface is little denuded, and many of the cones of loose scoria are almost perfect. It appears that the Newer Basalts mark the close of the last great movement which elevated the marine Kainozoics.

In New South Wales and South Australia earth movements on a grand scale took place during the Kainozoic period, yet volcanic action was comparatively insignificant.

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(8) On the Tertiary Alkali Rocks of Victoria. By Ernest W. Skeats, D.Sc., A.R.C.S., F.G.S., Professor of Geology and Mineralogy, University of Melbourne.

FROM Mount Leinster in Benambra, Frenchman's Hill near Omeo, and Noyang in Dargo, three areas in Eastern Victoria, the late Dr. Howitt (1) described igneous rocks which belong to the alkali series. They were all regarded by Howitt as of Palæozoic age. The age of the rocks of Noyang, which consist mainly of intrusions and lava-flows of quartz-ceratophyre, has not been closely investigated

and may be Palæozoic. Recent work (2), however, has shown, especially in the case of the Omeo rocks, that they are probably of mid- or even of late Tertiary age. The alkali rocks of Frenchman's Hill, described by Howitt as intrusive orthophyres, consist really in the main of lava-flows of anorthoclase trachyte which has a very scoriaceous margin to the flows. There is a central plug of a coarser quartz-bearing rock allied to solvsbergite and a more or less radial system of dykes which are principally trachytic in character. Some, however, contain quartz, one at least is a bostonite, and six or seven prove to be dykes of nepheline phonolite. The district is one which has been affected by a succession of elevatory movements of the plateau type since the mid-Tertiary period, and, according to Griffith Taylor (3), a more or less meridional Senkungsfeld runs through the Omeo District a few miles east of Frenchman's Hill. The rocks of Mount Leinster in Benambra consist principally of solvsbergites, bostonites, and pyroclastic rocks of alkali trachyte. Petrologically and chemically many of the rocks of Mount Leinster and of Frenchman's Hill closely resemble some of the alkali rocks of Mount Macedon, and, like them, are probably of mid-Tertiary age. The district has been elevated at intervals during the Tertiary period, but physiographically has not been closely studied.

About 14 miles north-east from Mansfield in North-Central Victoria and about 3 miles from Tolmie, in the Tolmie Highlands, there occurs a volcanic hill, known locally as Gallows Hill, which has recently been shown to consist of a volcanic centre of probably late Tertiary age and to consist of lava-flows of nepheline phonolite. From a locality near Barwite, east of Mansfield, another nepheline phonolite has been found, but its field relations are at present uncertain and no account of either of these rocks has yet been published. Fenner (4) has recently shown that block elevation and depression have affected the Mansfield area in recent geological times, and that Gallows Hill lies near one of the fault scarps.

The best-known area of alkali rocks in Victoria is the Mount Macedon District, about 40 miles north-west of Melbourne (5). The series is of mid Tertiary to late Tertiary age, and the rock sequence from below upwards, while not always demonstrable, appears to be as follows: anorthoclase trachyte, solvsbergite, anorthoclase basalt, macedonite, woodendite, anorthoclase-olivine trachyte, olivine-anorthoclase trachyte, limburgite. Immediately succeeding these alkali rocks come lava-flows of normal basalt and of andesitic basalt. The new types macedonite and woodendite contain over 1 per cent of P_2O_5, and are related to the orthoclase basalts and to the mugearites.

While this part of Victoria shows evidence, by the existence of more than one elevated peneplain, of successive movements of the plateau type, no definite evidence of faulting or differential movement has been recognized in the district. In the western district of Victoria more or less extensive lava-flows of anorthoclase trachyte occur near Coleraine, Carapook, etc. (6). Generally the trachytes appear to be older than the newer basalts, but near Coleraine a dyke of trachyte penetrates a small hill composed of a basic rock resembling

olivine basalt, while at the Hummocks north of Casterton another trachyte dyke similarly penetrates a vent or small flow of olivine basalt. Among the ejected blocks from the earlier members of the Pleistocene newer basalts of Lake Bullenmerri, near Camperdown, are some consisting of essexite and containing analcite. In the western district of Victoria clear evidence of comparatively recent elevatory movements is noticeable. No definite faults have yet been proved, however, and the normal basalts are much more widely spread than the alkali rocks. In view of Harker's generalization as to the close correspondence between the occurrence of alkali rocks and elevatory movements of the plateau type, generally accompanied by faulting, the above reference to earth movements is pertinent. Practically no folding movements are known among the Tertiary rocks of Victoria, while plateau movements, generally of elevation, sometimes of depression and accompanied by faulting, are widespread. Near Omeo and Mansfield, where faulting has been demonstrated or inferred, the highly alkaline types of nepheline phonolite are developed, but the widespread plateau movements in Victoria are more specially associated with the occurrence of the normal basalts. The alkali trachytes and allied rocks are intercalated between an older and a newer basalt series, are developed only sporadically at certain centres, and, as at Macedon, are closely associated in the field with the newer basalts as rocks of slightly greater antiquity but belonging to the same volcanic period.

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(9) On the Origin and Relationship of the Victorian Kainozoic Alkali Rocks. By H. S. Summers, D.Sc.

ALKALI rocks of Kainozoic age occur in Victoria in the Macedon District, near Coleraine and Carapook in the Western District, and in the neighbourhood of Omeo and Mansfield in North-Eastern Victoria. Ejected blocks from the volcanoes near Camperdown have been described as essexite, and a similar type, also probably ejected, has been found near Kyneton. With the exception of the occurrences of Omeo and Mansfield all these alkali rocks are closely associated with the Upper Kainozoic calcic basalts, and the field relations are such that there is little doubt that the alkali rocks and the basalts are genetically related.

Numerous analyses (mainly unpublished) have been made of Victorian basalts, and these show that they are fairly normal in

composition, and consequently should belong to Harker's Calcic or Pacific Branch of Igneous rocks, whereas the solvsbergites, trachytes, etc., of Macedon, the phonolites of Omeo and Mansfield, the essexites (?) of Camperdown and Kyneton, and the trachytes and anorthoclase basalts of the Coleraine area must be placed in the Alkali or Atlantic Branch. It follows, then, that the evidence of the Victorian Kainozoic rocks does not support Harker's generalization on Petrographic Regions.

A number of first-class analyses have been made of the principal types of the Macedon Series, and variation diagrams based on these analyses have been drawn (see Bulletin of the Geological Survey of Victoria, No. 24, 1912, and Proceedings of the Royal Society of Victoria, N.S., vol. xxvi, pt. ii, 1914). It was found that by re-calculating the analyses to 100 per cent with the water omitted and the ferric oxide reduced to ferrous, the curves obtained were better than those plotted from the original analyses. Certain of the analyses did not conform to the curves, and at first these were regarded as representing hybrid types, but additional work showed that they represented complementary types and resulted from the splitting up of a magma instead of the mixing of magmas. A few analyses have been made of the alkali rocks from other Victorian areas, but a sufficient number have not been made to show the relationship of the various types to one another.

The conclusions are that the Kainozoic alkali rocks of Victoria are derived from the calcic basalts by differentiation, giving rise to several lesser magma reservoirs. In the case of the Macedon magma further differentiation took place, and a series of lavas were extruded which in general showed a serial relationship to one another, but a certain number were complementary to one another.

REVIEWS.

I.—Igneous Rocks and their Origin. By R. A. Daly, Sturgis-Hooper Professor of Geology, Harvard University. New York and London, 1914.

EVERY field-student of igneous intrusions must at some period of his career have been confronted by the following problem: before the intrusion occurred, what occupied the space now filled with igneous rock, and what has become of that material? Up to the present time this problem has scarcely been considered by British petrographers, at any rate in print, whatever may have been their private speculations on the subject. This is the most important question that the author of this book sets out to answer; if, after reading it, we are not perhaps prepared to accept all his conclusions in full in exactly the sense intended by the author, it is at any rate clear that he has provided abundant food for thought among petrologists.

Professor Daly has long been known as an advocate of *stoping* as an important mechanism in rock-intrusion. Now, stoping is merely another name for assimilation, since it implies the fusion and

incorporation of blocks of the country rock sinking in the invading magma. Many of the older petrologists believed that igneous intrusions, such as granite, were formed by the simple fusion in place and recrystallization of 'country rock' normally sediments. Chemical analysis soon showed this hypothesis to be untenable in such a simple form, but Professor Daly's ground idea is really a modification of this; he postulates an original acid granitic shell, underlain by a basic basaltic shell; by mixtures of these, and by mixtures of basaltic magma and sediments (syntectics) assisted by differentiation, he derives all possible igneous rock-types, in many cases with much plausibility. It is important to note that this theory does not propose to explain fully the igneous history of the earliest pre-Cambrian times; it only professes to deal with the phenomena of later pre-Cambrian (post-Keewatin) and post-Cambrian times. The earlier events seem to have consisted largely in the differentiation by gravity of the fundamental granitic and basaltic shells. The later events are explained in large part as due to the penetration of wedges of the underlying basaltic magma into the granitic shell and into the sediments that subsequently came to overlie it.

One of the chief lessons to be learnt from a careful reading of this book is the unimportance, in fact even the danger, of an elaborate nomenclature. The names applied to rock varieties are legion; some 700 different rocks have been defined and indexed; a very large proportion of these are varieties of the so-called alkaline rocks. Hence we obtain a distorted and unnatural idea of the importance of this group. When, however, the quantitative method is applied, as is done by Professor Daly, things soon begin to appear in more accurate proportion. It is estimated by the author that in North America the alkaline rocks amount to less than one-tenth of 1 per cent of all the igneous rocks, perhaps even less than this, and in Europe certainly to less than 1 per cent. Here, then, the appalling list of rock-species of alkaline type, including pulaskite, kakortokite, naujaite, lujaurite, ouachitite, bekinkinite, and many other efforts of a diseased petrological imagination, sink into their true insignificance, and the great fundamental fact emerges that the alkaline rocks as a whole are only incidental products of a planet whose eruptions and intrusions have been overwhelmingly of sub-alkaline quality. Furthermore, from this quantitative treatment, it is clear that basic sub-alkaline rock-types predominate in the extrusive phase of igneous action, acid sub-alkaline types in the intrusive phase, or, in other words, abundant evidence is brought forward to show that the normal rock-types of the world are granite and basalt. Apart from theory, this is a fact of observation resting on statistics accessible to all, and geologists are much indebted to Professor Daly for having laid emphasis on such an important, but for long unrecognized, truth.

In the light of these facts, the great and commonly accepted division of rock-species into Atlantic and Pacific types loses most of its force, at any rate in so far as concerns their connexion with different types of earth movement, or with actual geographical

distribution. The same applies with perhaps even more cogency to the recent attempts to introduce a third, spilitic, series, which appears to differ in no fundamental character from either of the other two. The spilites appear to be simply normal basalts in which the soda molecule has been concentrated by some kind of pneumatolysis or differentiation, which in this respect are really much the same phenomenon under different names.

Perhaps the least satisfactory part of the whole treatment is the explanation that is offered for the highly alkaline rock-types, nepheline syenites, phonolites, leucite rocks, and so forth. For this is given what appears at first sight the paradoxical explanation that they are due to the assimilation by sub-alkaline magmas of limestone or dolomite. These materials are supposed to act as powerful fluxes, greatly facilitating the differentiation of the magma, and leading to concentration of its salic constituents in one portion and its calcic and femic molecules in the other portion. Evidence is brought forward to show the extremely common association of such exaggeratedly alkaline rock-types with limestones in rocks of all ages. Here and elsewhere great importance is attached to the idea of the so-called 'two-phase convection' as an agent of differentiation. Space will not here permit of a discussion of the validity of this conception, which is obviously of very great importance.

It only remains to express the thanks of the petrological world to Professor Daly for bringing forward such a notable contribution to scientific petrology, which is bound to have a far-reaching effect, and by its frank and fearless discussion of many accepted dogmas must eventually help us in our slow progress towards the truth.

R. H. R.

II.—The Water Supply of Nottinghamshire from Underground Sources. (Memoirs of the Geological Survey, England and Wales.) By G. W. Lamplugh, F.R.S., and B. Smith, M.A.; with a chapter on the rainfall by H. R. Mill, D.Sc., LL.D. pp. 174, with 2 plates and 2 text-figures. Price 5*s*.

THIS memoir forms a notable addition to the series on the Water Supply of English Counties. The underground water is of great economic importance, since almost the whole of the supply is now derived directly from this source, the surface-water being in nearly every instance too much contaminated for use. The rocks of the county are fortunately peculiarly well adapted for the absorption and storage of the rainfall, and the most extensive of the water-bearing formations is conveniently situated for the supply of the industrial centres.

In ch. i an outline is given of the arrangement and character of the geological formations. The general dip of the strata is to the east in the northern part of the county, swinging round to the south-east in the southern part, and it is almost everywhere at a low angle, rarely so much as 5 degrees. A geological map on the scale of 4 miles to 1 inch forms plate i, and on this lines are drawn to indicate the contours of the top of the Bunter beneath the overlying formations,

at depths below Ordnance Datum, at intervals of 200 feet. The outcrop of the Bunter Pebble Beds and Lower Mottled Sandstone occupies an area of 240 square miles in the county, and it is from these beds that most of the water is derived. A sketch-map of part of North Nottinghamshire shows the underground water-level in the Bunter in 1909; the contours of the water-table are drawn at 5 ft. intervals, and the height above O.D. is given in feet. It is estimated that the yield, from the Bunter, of public wells is about fourteen million gallons a day, and of private wells about seven or eight million gallons.

In ch. ii it is noted that the average rainfall responds to the configuration of the county in a striking manner. The lowest rainfall, less than 25 inches, is confined to the low ground of the Trent Valley, and the isohyetal line of 25 inches coincides roughly with the contour-line of 150 feet of elevation in the south and that of 100 feet in the north. The isohyetal of 30 inches keeps near the contour of 500 feet in the west of the county. The local description of the water supply is dealt with under five districts, which are partly topographical and partly geological, and references are here given to the fuller geological and other details contained in the subsequent chapters, in which the records of well-sections and a large number of analyses are brought together.

III.—Classification des Lamellibranches. Par H. Douvillé. Bulletin Société Géologique de France, ser. iv, tom. xii, pp. 419–67, figs.

THIS paper, owing to its publication in a journal not open to all, runs the risk of not receiving the attention it deserves.

After summarizing the various systems of classification that have been proposed for the Pelecypoda, beginning with that advanced by Neumayr in 1883, the author discusses the nature and development of the shell and roughly divides the group into those that live free, those that are attached, and the crypt dwellers or burrowers.

Three types of characters attach to the Pelecypoda.

1. *Evolutionary characters.* Thus in the ancient forms the shells were nacreous, but became porcelainous in their descendants during the course of their evolution.

2. *Adaptive characters* due to environmental conditions and giving rise to like forms of test in animals of distinct stocks, e.g. *Mytilus* and *Dreissensia*, *Ostrea* and *Chondrodonta*, *Solen* and *Ensis*, etc.

3. *Static characters*, or those which change least. The hinge is the best example of this type and is consequently the one mainly relied on by the author for the purposes of classification.

An extremely interesting and well-illustrated section follows, giving the different forms of hinge and their evolution, whilst the paper concludes with a tabular statement of the phylogenetic grouping proposed.

This shows the primitive nacreous forms divided into three groups; Taxodonta, comprising the free forms; Dysodonta, or fixed forms; and Desmodonta, or crypt dwellers and burrowers, including such

forms as the Corbulidæ, etc., that have secondarily become free but retain the hinge characters of the group.

In the Taxodonta, through *Ctenodonta* and *Palæonilo* arise the Nuculidæ and kindred forms; whilst through *Actinodonta* spring on the one hand the Anthracosiidæ and Unionidæ, and on the other *Modiomorpha* and a group to which the name Preheterodonta is applied. This last in turn gives off two branches, the one comprising the Myophoridæ and Trigoniidæ, the other leading through *Megalodon* to the Heterodonta.

The Dysodonta have also two branches: firstly, *Palæarca* and the Arcidæ; and secondly, Pterineidæ, giving off the Mytilidæ (with *Conocardium* and *Lunulicardium*) and the Aviculidæ (i.e. Pteriidæ), Pectinidæ, Limidæ, and Ostreidæ.

Finally, the Desmodonta, beginning with the Solenopsidæ, pass up through the Grammysiidæ to the forms usually included under Myacea, Adesmacea, and Anatinacea.

To what extent M. Douvillé's scheme will stand the test of close investigation remains to be seen. Probably his interpretation of the hinge characters may in certain cases have to be revised, but the broad outlines seem well conceived, and his paper merits the careful attention of all interested in the Mollusca.

B. B. W.

IV.—Catalogue des Invertébrés fossiles de l'Égypte représentés dans les Collections du Musée de Géologie au Caire. Par R. Fourtau. Terrains Crétacés. 1re partie: Échinodermes. 4to; pp. i–vii, 1–109, pls. i–viii. Cairo: Geological Survey of Egypt, Palæontological Series, No. 2.

IF the present rate of output is maintained the collections of the Geological Museum at Cairo will soon rank among the most completely and thoroughly catalogued material extant. The first part of the Catalogue, dealing with the Eocene Echinoids, was reviewed recently in these pages, and now the second part is published. The style and production of this volume leave little field for criticism. It is perhaps a little confusing that, whereas the first part had a title-page printed entirely in French, the present part has all but the actual name of the work in English.

The number of misprints seems to be remarkably small, a gratifying feature in view of their serious frequency in the first part. The plates are, if anything, clearer both in drawing and execution than were the previous series, and their concentration at the end of the volume renders them easier of access than did their insertion in various parts of the text.

Although Asteroids and Crinoids are mentioned in the work, there is little fresh material recorded. A new genus, *Spenceria*, is proposed for *Metopaster teilhardi*, the name being given in recognition of the work of Mr. W. K. Spencer on Cretaceous Asteroids. The bulk of the volume is occupied by a descriptive catalogue of no fewer than 122 species and varieties of Echinoids, of which but a small proportion are new. In common with many other workers on

Echinoids, M. Fourtau seems to be appalled by the great number of species that are accumulating under certain generic names, and he attempts to mitigate the evil by degrading certain 'species' to the ranks of varieties, races, and mutations. This method seems fully justifiable, so long as it is carried out uniformly. Unfortunately M. Fourtau does not give any indication of the precise significance (for him) of the three subspecific terms employed. It is possible, from a study of the actual cases, to glean some information on this score, but a simple statement, or a definition, would have rendered the process of 'despecification' more intelligible. It seems that, for M. Fourtau, a 'variety' is a form that differs from the type in some slight respects, but may be discovered over wide areas, including the type locality; while a 'race' is a local variant confined to some region other than the type locality. There is not sufficient evidence to speculate on the propriety or otherwise of the use of the much harassed term 'mutation'.

An interesting feature of the variation of some of the species of *Hemiaster* is the parallelism of the lines along which they tend to vary. Thus the four different forms of *H. cubicus* are matched closely by a corresponding four in *H. heberti*. Here surely is further evidence in support of the principle of the fixity of the trend of evolution among separate but homogenetic races—a principle that has been urged by the present writer in several recent papers.

There is little of outstanding interest in the new species described in the Catalogue, if we except the *Schizaster*. A fresh bridge has thus been thrown across the Cretaceo-Eocene gulf by the occurrence of so essentially Tertiary a genus in the Maestrichtien.

One further aspect of the work demands comment. In the Introduction M. Fourtau refers to a suggestion (made in the review of the previous volume) that he should not confine his efforts to mere description, but give to the world the ideas that his acquaintance with these numerous Echinoids has surely engendered. He contends that a catalogue is not adapted for the expression of personal opinions on the material dealt with. Granted, but there are other channels of publication. M. Fourtau also seems to infer that, until all the material is known and systematized, conjecture and theory are alike premature. Surely here he resigns himself to perpetual silence; there will be fresh material appearing throughout his lifetime, long as we hope that period may be. Indeed, such a suggestion, whether it is prompted by tenderness of conscience or feebleness of courage, is in every way to be condemned. The average human mind is not a mere machine for the production and arrangement of species and genera after the manner of a cash-register. These must be strung together into a chain of evolution, even if some of the links have to be imagined. The spurious links may be faulty, and require frequent renewal or replacement, but, when some of the links are in their right order, the rest can in time be adjusted. To change the simile, M. Fourtau spreads before us many of the wheels, screws, and springs of an intricate machine, all loose and in disorder. He, more than any man, is capable of judging as to which cogs fit and which portions are lost. Every year adds to the pile of fragments, and

they are getting bewildering in their profusion. Cannot a *few* of them be fitted together *now*?—thus only can we hope to understand the meaning of the rest.

H. L. H.

V.—The San Franciscan Volcanic Field, Arizona. By Henry Hollister Robinson. United States Geological Survey, Professional Paper 76. pp. 213, with 14 plates and 36 text-figures. 1913.

THE San Franciscan volcanic field, which takes its name from San Francisco Mountain, the largest volcano of the group, covers about 3,000 square miles in the north-central part of Arizona. The State is divided into the Plateau and Basin Range provinces, and the latter is subdivided into the Mountain and Plains districts. The topography of these divisions is discussed and an account is given of the particular features of the volcanic field, which is situated in the Plateau province.

The description of the drainage of the area is of much interest, especially the examples of the changes caused by the damming of watercourses by lava-flows. A chapter is devoted to the sedimentary rocks, the structure, and the glaciation and alluvial deposits of San Francisco Mountain. The oldest rocks of the region are of Mississippian (Lower Carboniferous) and Pennsylvanian (Upper Carboniferous) age, and furnish a record of continuous marine sedimentation. The Mœncopie formation, which is probably of Permian age, rests on a somewhat eroded surface of the older rocks, and consists of fluviatile or shallow-water deposits. Then follow Triassic sandstones, shales, and marls which show evidence of continental deposition. No traces are left of the Jurassic, Cretaceous, and possibly Eocene strata which once covered the area.

The phenomena of the volcanic region are dealt with at length. Three general periods of volcanic activity, separated by intervals of quiescence are recognized. The phenomena of the first period were of a simple nature, and consisted of widespread eruptions of basalt from small cones. During the second period various lavas, ranging from andesites to rhyolites, were erupted and built up a few large cones. This period was further marked by laccolitic and semi-laccolitic intrusions contemporaneous with the volcanic extrusions. The third period closely resembled the first in that it witnessed the eruption of a single lava, again a basalt, but it was characterized by the formation of a larger number of cones and a less widespread distribution of the lava. Each period receives separate treatment, and the details of the character, extent, and conditions of extrusion of the erupted material are carefully worked out and illustrated by maps and photographs of the principal cones.

There is an interesting chapter on the history of the volcanic field and adjacent country. This is followed by chapters on the petrography and petrology, in which the detailed description and classification of the igneous rocks and the differentiation and composition of the magma are dealt with. Analyses are given of all the important rock types.

OBITUARY.

H. J. JOHNSTON-LAVIS, M.D., M.R.C.S., F.G.S.,

VITTEL, VOSGES, FRANCE.

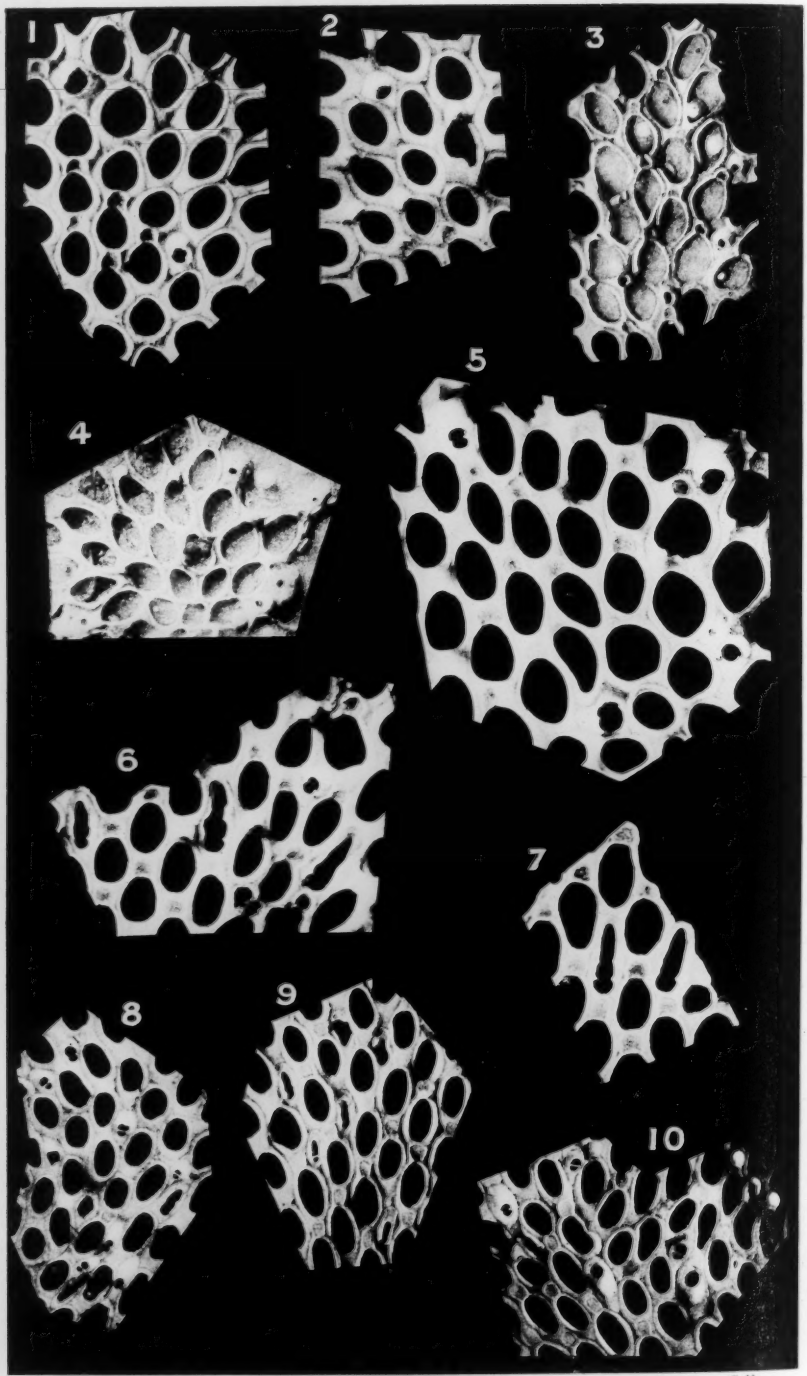
As we go to press we learn with great regret that Dr. H. J. Johnston-Lavis has been killed in a motor accident at Bourges (Department of Cher), France. He appears to have been on his way from Paris taking his invalid wife to their daughter at Biarritz. Madame Lavis escaped. We hope to give an obituary notice in a later number of the Magazine.

MISCELLANEOUS.

The Type of Pliolophus vulpiceps, Owen.—In 1858 Richard Owen described the head and other portions of a skeleton of a small mammal from the London Clay of Harwich under the name of *Pliolophus vulpiceps*. He had made a section through the lower jaw, and that section was, so far as we knew, the only fragment of the original skull which survived. It is in the British Museum. The specimen belonged to the Rev. R. Bull, vicar of Harwich, and was supposed to have perished. Such was a tradition with the late Mr. William Davies, and Woodward and Sherborn failed to trace it when writing their *British Fossil Mammalia*. But only two weeks ago a message was received from the widow of Mr. Bull saying that the specimen was not only preserved but that she wished to deposit it in the British Museum in accordance with her late husband's desire. The little skull and limb bones are as perfect as when Owen left them, and still bear his labels. The section of the jaw now in the Museum fits on exactly to the cut in the skull.

The recovery of this long-lost type is of extraordinary interest, for it is the earliest known horse, and its proper position is ascertained from work done since its time in America and elsewhere. It is greatly to be hoped that the specimen may be redescribed in the light of modern knowledge, and the thanks of all palæontologists are due to Mrs. Bull, who has so carefully preserved the specimens and handed them over to the British Museum, where they will be available to students from all countries. The modern name of the animal is *Hyracotherium leporinum*, Owen, for *Pliolophus vulpiceps* proves to be identical with a species founded in 1841.

The Fossil Track of a dying Lobster.—Dr. J. Walther has remarked that very few of the Crustaceans preserved in the Kimmeridgian Plattenkalk at Solnhofen exhibit traces of a death-struggle or of any movement, and he infers that these and other forms of life were dead before their remains were swept into the basin where the Plattenkalk was accumulated. In *Knowledge* for September Dr. F. A. Bather describes and figures a specimen of *Mecochirus longimanus*, one of the Glyphæidæ, accompanied by tracks indicating the movements that took place during the last few minutes of its life. From the nature and the distinctness of the markings it is inferred that the animal had been thrown on to a mud-flat exposed for a time to the direct rays of the sun. The specimen is numbered I 16137 in the Geological Department of the British Museum.



R. M. Brydone, Photo. Bemrose, Collo.

Chalk Polyzoa.